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ABSTRACT

An experiment investigated the effects of representational modes, presentation methods, and age on learning. Representation was in either iconic or symbolic verbal style, the verbal component was presented by either tape or booklet, and the pictorial component contrasted filmloops. Nine and eleven year old learners were exposed to a lesson on the concepts of flipcard animation. The main results were the following: the iconic and symbolic modes did not differ in effectiveness; filmloop and filmstrip were equally effective; and the tape/filmloop treatment was more effective than booklet/filmloop, but booklet/filmstrip was more effective than tape/filmstrip. (Author/RH)

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MEDIA PRESENTATION AND CONCEPT REPRESENTATION VARIABLES IN INDEPENDENT LEARNING

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CONTENTS

	Page
SUMMARY	1
Chapter	
I. INTRODUCTION	3
The Problem	3
Objectives of the Study	4
Review of Related Literature	5
Media Theorizing	8
II. DESIGN AND METHODOLOGY	19
Experimental Design	19
Experimental and Organismic Variables	19
Experimental Materials	22
Measurement Instruments	27
Dependent Variables	29
Experimental Populations	29
Facilities and Equipment	29
Conduct of the Experiments	31
Statistics	32
Data Processing	34
Research Hypotheses Investigated	34
III. RESULTS	37
Hypotheses of No Significant Differences	37
Summary of Findings Relative to General Hypothesis 1.0	43

Chapter Page

Hypotheses of Differential Effectiveness 43

Summary of Findings Relative to General Hypothesis 2.0 48

Hypotheses of Significant Differences in Efficiency 49

Summary of Findings Relative to Hypothesis 3.0 53

Hypotheses of Differential Efficiency 53

Summary of Findings Relative to Hypothesis 4.0 59

Significant Age Differences 63

IV. CONCLUSIONS, DISCUSSION AND MAJOR FINDINGS 65

The Congruence of Modes 65

Modes Variable 65

Verbal Media Variable 65

Pictorial Media Variable 68

Interactions of Variables 68

Measures 68

Paradigm 69

REFERENCES 71

APPENDICES:

Appendix A. Iconic and Symbolic Texts of the Multimedia Lessons 77

Appendix B. Written Test Booklet and Performance Text Checklist 87

Appendix C. Sample Page from the Booklets Accompanying Filmstrip Multimedia Lessons 101

Appendix D. Analysis of Variance Tables for Experiments One Through Four 105

SUMMARY

The purpose of this study was to utilize and assess the feasibility of a media research paradigm which separates for analysis the modes by which concepts are represented from the media by which they are presented in independent learning settings.

Objectives

The general objectives of the study were:

1. To determine the effects of two modes of representing concepts in the verbal component of a multimedia lesson.

2. To determine the effects of two media presenting the verbal component of a multimedia lesson.

3. To determine the effects of two media presenting the pictorial component of a multimedia lesson.

4. To determine the interrelationships among representation modes, presentation media, and age levels (assumed to represent differing levels of cognitive functioning).

5. To assess the import of the experimental paradigm for media theory, research, and design.

Procedure

The study consisted of four related 2x2x2 experiments. Eight separate media treatments of a lesson on concepts of flipcard animation were prepared for use in the four experiments. The effects of four variables were studied. The mode of representation variable contrasted two verbal styles, termed Iconic and Symbolic. One presentation variable—the media presenting the verbal component—contrasted Tape and Booklet. The second presentation variable—the media presenting the pictorial component—contrasted super 8mm Filmloop and Filmstrip. The organismic variable contrasted 9- and 11-year-old learners. In each of four experiments elementary pupils were randomly assigned to four treatments, 48 subjects in each of two experiments, and 47 in each of the two remaining experiments. All subjects completed the media treatment and tests, individually, in independent learning settings. Measurements of performance were made by transfer-of-learning tasks and an objective test. Time-to-completion data were recorded for treatment, transfer tasks, and objective test. The general linear hypothesis, *F* test, *t* test, and a test of power were employed in the analyses of the data.

Results and Conclusions

The results and conclusions of the study are summarized:

1. There was no substantive evidence of a congruence of modes of representing concepts in multimedia lessons and of age levels.

2. It was concluded, with confidence, that Iconic and Symbolic modes of concept representation did not differ, significantly, in effectiveness.

3. It was concluded, with confidence, that Filmloop and Filmstrip multimedia lessons did not differ, significantly, in effectiveness.

4. The Tape/Filmloop treatment was more effective than the Booklet/Filmloop treatment, but the Booklet/Filmstrip treatment was more effective than the Tape/Filmstrip treatment.

5. Booklet treatments tended to be more time efficient than Tape treatments.

6. Results of the four experiments suggested a possible three-way interaction among verbal and pictorial Media and Modes, interactions not directly investigated in this study.

7. A subtest composed of verbal-type items appeared to be more sensitive to interactions among variables than pictorial or performance tests.

CHAPTER I

INTRODUCTION

This exploratory study investigated, in four separate but related experiments, the relationships among representation modes, presentation media, and age levels in an attempt to contribute information relevant to the development of paradigms for media theory and research and relevant to the development of principles and guidelines for the design of media used in independent learning settings by young learners.

The Problem

The purpose of this study was twofold. First, it was to assess the feasibility of a media research paradigm which separates for analysis the modes by which concepts are represented from the media by which they are presented. Second, it was to investigate the efficiency and effectiveness of two modes of representing concepts, two media presenting verbal components of instruction, and two media presenting pictorial components of instruction as they interact with one another and with two age levels of elementary school pupils in independent learning settings. An assumption basic to the experimental design was that the two age levels differ in levels of cognitive functioning.

In brief, eight multimedia treatments were designed and produced for a lesson on flipcard animation. Various combinations of these treatments were used in four related, 2x2x2 experiments conducted in southern California elementary schools. In each experiment, nine-year-olds and eleven-year-olds were randomly selected and assigned to four media treatments. The first experiment investigated the main effects and interactions of age levels (9 and 11), media (filmstrip and filmloop), and modes of representation (iconic and symbolic) under the conditions of presentation of the verbal component of instruction by means of audio tape. The second experiment investigated the same effects under the conditions of presentation of the verbal component by means of a booklet. The remaining two experiments investigated the main effects and interactions of age (9 and 11), media (audio tape and booklet), and modes (iconic and symbolic). The third experiment investigated the main effects and interactions under the conditions of presentation of the pictorial component by means of an 8mm filmloop. The four experiment investigated the same effects under the conditions of presentation of the pictorial component by means of a filmstrip.

In all four experiments the principal dependent variables were (1) scores of an objective test composed of pictorial- and verbal-type items, (2) performance scores for a series of flipcard tasks, and (3) measures of the time required to complete the media treatments. In

addition, scores for pictorial and verbal subtests as well as measures of the times required to complete the set of transfer tasks, the objective test, and the entire experimental process were considered as dependent variables.

Computer programs applying the general linear hypothesis model were used to analyze the data for each dependent variable. For each dependent variable certain preplanned comparisons (t tests) were made to test hypothesized differences between means. Where no differences were hypothesized (i.e., none expected), a test of power developed by Nielsen (1970) was used to estimate the confidence level for findings of no significant differences.

In general, all four experiments in this study are related in that:

1. Each media treatment was one of eight specially prepared multimedia combinations.

2. Each experiment followed nearly identical experimental procedures.

3. Each experiment had the same dependent variables and used the same measurement instruments and analyses.

4. All four experiments investigated common variables of instructional media design.

In sum, the problem was to design, produce, and test, under controlled conditions, various combinations of media (treatments) to provide evidence concerning the relationships among representation modes, presentation media, and age levels. The study engaged this problem in an attempt to find information relevant to the development of paradigms for media theory and research and relevant to the development of principles and guidelines for the design of media used in independent learning settings.

Objectives of the Study

The main experimental objective of the study was to investigate in independent learning settings the comparative effectiveness and efficiency of three media variables with two age levels assumed to differ in levels of cognitive functioning. Specifically, the objectives were:

1. To determine the immediate effects--in terms of effectiveness and efficiency--of two modes of representing concepts in the verbal component of a multimedia lesson.

2. To determine the immediate effects--in terms of effectiveness and efficiency--of two media presenting the verbal component of a multimedia lesson.

3. To determine the immediate effects--in terms of effectiveness and efficiency--of two media presenting the pictorial component of a multimedia lesson.

4. To determine the immediate interaction effects--in terms of effectiveness and efficiency--of representation modes, presentation media, and age levels.

5. To determine the above effects when measured by pictorial and verbal-type test items, transfer tasks, and a combination of such measures.

6. To assess the import of the experimental paradigm for media theory, research, and design.

Review of Related Literature

The literature relative to this study will be reviewed in the following five sections. The first and second sections review the literature relative to the bases of the experimental design and to two developmental and cognitive theories. The third and fourth review the literature relative to media theorizing and to media design and selection. The fifth reviews the research relative to the modes and media variables.

The Experimental Paradigm

The experimental paradigm employed and assessed in this study was developed originally in an exploratory study by Nielsen (1970). Noting that little substantive theory and few specific findings had emerged after more than fifty years of media research, Nielsen suggested that part of the failure had been fundamentally conceptual: That most experimental designs had not separated for analysis the physical, presentation characteristics of the media from the modes by which the content was represented. Furthermore, he noted that researchers had failed to design studies which investigated interactions of media design variables with developmental variables of cognitive functioning.

After reviewing theoretical positions of epistomologists, Susanne Langer (1942, 1962) and Jean Piaget (Flavell, 1963), cognitive psychologist Jerome Bruner (1967), and such media theorists as Gibson (1954), Knowlton (1966), and Conway (1968), Nielsen suggested that there existed a potential isomorphism of theoretical constructs which promises a new synthesis of cognitive and developmental theory and media theory. In his study, Nielsen postulated: "... a probable and potentially significant congruence of modes of knowing (intellectual functioning, as articulated by Piaget, Bruner, and others) and modes of representation in the media of instruction [Nielsen, 1970, p. 31]."

The experimental paradigm, designed to test hypotheses derived from such a postulate, separated such a modes variable from other media

variables and from age, thus permitting an investigation of the variables' main effects and, most importantly, their interactions.

In essence, Nielsen's exploratory study was a pilot of this study, establishing the theoretical bases for the experimental paradigm and investigating media and modes variables under the same conditions as those in the fourth experiment of this study (i.e., investigating the main effects and interactions of iconic and symbolic modes, audio tape and booklet media on ages 9 and 11, with filmstrip multimedia lessons).

Developmental and Cognitive Theories

The developmental and cognitive theories of Jean Piaget, Swiss biologist, psychologist, and epistemologist; and Jerome Bruner, American educational psychologist; are of particular relevance to the theoretical position assumed in this study. Both theoretical positions recognize the dual nature of symbolic functioning and the developmental progression from imagery to language.

Piaget's three periods of intellectual development. Piaget's theoretical system is, in particular, oriented towards a biological study of the structure of developing intelligence. Crucial to the link between biology and intelligence are the structural invariants of organization and adaptation, the latter of which is composed of two dialectic processes, assimilation and accommodation. By "changing elements in the milieu in such a way that they can be incorporated into the structure of the organism," the organism assimilates the elements to his system (Flavell, 1963, p. 45). By adjusting its structures and functioning to those elements, the organism accommodates. For Piaget, the ontogenetic development of cognitive structures (organizations) is "a process of successive approximations to a kind of ideal equilibrium" by means of the dialectic acts of assimilation and accommodation (Flavell, 1963, p. 47).

Piaget asserts there are three general developmental periods of human intellectual growth, each achieving a distinctive kind of equilibrium. During the period of sensory-motor intelligence (0-2 years) the infant progresses "from a neonatal reflex level of complete self-world undifferentiation to a relatively coherent organization of sensory-motor actions vis-a-vis his immediate environment [Flavell, 1963, p. 86]."

The second period (2-11 years), starting with the first crude symbolization late in the sensory-motor period and concluding with the beginnings of formal thought in early adolescence, is divided into two important stages. During the first stage of preoperational representations (2-7 years), a symbolic function emerges, permitting the child to differentiate signifiers from significates and thereby, to develop simple, and later, articulated representations and intuitions. During

the second stage (7-11 years) of concrete operations, the child develops a rational and "fairly stable and orderly conceptual framework which he systematically brings to bear on the world of objects around him [Flavell, 1963, p. 86]."

The final period of formal operations (11-15 years) leads to the reorganization of cognitive structures which become isomorphic with groups and lattices of logical algebra, permitting the adolescent and adult to deal not only with reality, but also with the purely possible, with the hypothetico-deductive world of abstract propositional statements and thought.

In sum, Piaget's theoretical system identifies three qualitatively and functionally different developmental periods of intelligence. Initially, the infant develops a sensory-motor intelligence founded and articulated in actions. Later in childhood, the activation of the symbolic function leads to an intelligence of "interiorized" patterns of actions (operations) and representations (images, language, and other symbols) used systematically in dealing with the concrete, the real. Finally in adolescence, completion of systems of operations related to logico-mathematical structures ends with a formal operational intelligence which is used, systematically, in dealing with not only the concrete and real, but also the abstract and hypothetical.

Bruner's three modes of representation. Jones (1966) has described Bruner's position as a "psychology of alloplastic development, of the forms in which knowledge is best brought into the organism and the forms in which it is best put out again [p. 123]." Bruner takes a technological view of cognitive growth. For him growth is dependent upon the mastery of techniques, skills transmitted with varying efficiency and success by the culture. He asserts that man has changed over the past 500 thousand years or so "by linking himself with new, external implementation systems rather than by any conspicuous change in morphology [1966, p. 123]."

Bruner identifies three general systems of such implements; amplifiers of human motor capacities, amplifiers of sensory capacities, and amplifiers of human ratiocinative capacities. Furthermore, he asserts that "any implement system, to be effective, must produce an appropriate internal counterpart. . . . We move, perceive, and think in a fashion that depends upon techniques rather than upon wired-in arrangements in our nervous system [1966, p. 125]."

The techniques which internalize counterparts to the external world are modes of representation. The three modes--enactive representation, iconic representation, and symbolic representation--are viewed as developing, in that order, in infancy and childhood, and remaining more or less intact throughout life.

Enactive representation is a mode of representing past events

through appropriate motor response. Iconic representation involves the selective organization of percepts and images. Symbolic representation, for Bruner, is most frequently associated with language, whereby events are represented by symbols and symbol systems which are, in relation to referents, distinctively arbitrary and remote in their form. Bruner explains that the symbolic mode "stems from a form of primitive and innate symbolic activity that, through acculturation, gradually became specialized into different systems [Bruner, Olver, et al., 1966, p. 30]."

In sum, Bruner's technological view of cognitive growth is explained by three systems of representation, which are ways for dealing with information.

> The growing child begins with a strong reliance upon learned action patterns to represent the world around him. In time, there is added to this technology a means for simultanizing regularities in experience into images that stand for events in the way that pictures do. And to this is finally added a technology of translating experience into a symbol system that can be operated upon by rules of transformation that greatly increase the possible range of problem-solving [Jones, 1966, pp. 146-147].

An assumption of relevance. In this study the modes or styles of representing concepts to be learned, as well as the assumed levels of cognitive functioning, were derived from Bruner's systems of representation.

An assumption basic to this study was that if there is a congruence of systems or modes of cognitive functioning and modes of representing concepts in instructional events, then information derived from this study would be of value in the effective design and selection of media used in such instructional events.

Media Theorizing

Hoban, Hoban, and Zisman (1937) were the first in the audio-visual movement to recognize the need "to examine processes of mental growth and to derive the psychological principles which apply to the values and uses of visual aids [Hoban, Hoban, & Zisman, 1937, p. 16]." They proposed progressive stages of development and concluded that such was first demonstrated by Brownell (1928) in his study of the mental processes of children in arithmetic in primary grades. These early theorists also were first to differentiate "sign" representations from "symbolic" representations, a distinction to be further developed and applied by Gibson (1964), Knowlton (1966), Conway (1967, 1968), and others.

"Representation" in media theorizing. Gibson (1954), in pro-

posing a theory of pictorial perception, chose to develop the concept of a surrogate, "an artificial stimulus produced by another individual which is relatively specific to some object, place, or event not at present affecting the sense organs of the perceiving individual [Gibson, 1954, p. 7]." The surrogates come to mediate in perception that which they correspond to in reality, making possible vicarious experiences, the exchange of surrogates (communications), and a common body of perceptions (knowledge).

For Gibson, thinking can be in terms of image surrogates as well as symbolic surrogates, the first being considered projective or replicative of perceptual properties while the latter are considered conventional and arbitrary. In terms of principles of application, Gibson concluded that when perceptual properties were to be learned, realistic non-conventional surrogates (images) were to be used, but when abstract properties, principles, and generalizations were the instructional objectives, then the arbitrary and conventional surrogates (symbols) were most appropriate. It is particularly noteworthy that Gibson considered his theory as being only specific to the features of the environment and not to the state of the organism.

Knowlton (1966) reported on progress in developing a metalanguage for talking about pictures. He chose to differentiate between iconic and digital sign vehicles, the sign vehicle being the physically embodied word or picture, while the sign was the evoked disposition to respond to it. For Knowlton the digital sign was arbitrary in its form while the iconic sign's form was logically related to the form of its referent.

Having once made the distinction between the two types of signs, Knowlton proceeded to concentrate upon the iconic sign. For him it requires postconceptual status to be used, i.e., that the concept which it signifies has already been attained by the interpreter of the sign. "The concept is not signified but exemplified [Knowlton, 1966, p. 167]."

Knowlton viewed the context, particularly the verbal context in the instructional situation, as greatly determining the meaning of a sign. To accommodate this fact, he proposed a taxonomy which, instead of making categorization dependent upon the sign vehicles' physical attributes, requires that the iconic sign be analyzed in a way that takes account of the verbal context in which it is embedded. The taxonomy formed a 3x3 matrix with the constituent parts of the iconic representation--elements, patterns of arrangement, and order of connection--comprising one dimension, while realistic, analogical, and arbitrary relationships between sign and its referent were the levels of the other dimension. According to Knowlton, a picture may be classified one time as realistic while another time analogic since the context and its correspondence to its referent would determine in which cell it would be placed.

In the summary of his presentation, Knowlton acknowledged the potential of the iconic image to markedly affect the digital, verbal language. Referring to a study of Hadamard (1945) on the kind of

imagery outstanding scientists and mathematicians used in solving new and difficult problems, Knowlton noted:

> Most agreed, as did Einstein (who was one of the respondents), that words and numbers had to be supplemented when first dealing with unusually intractable problems on the frontiers of knowledge. Describing his own case, Einstein reported that he often used visual and kinesthetic images when coping with difficult problems . . . [Knowlton, 1966, p. 181].

Conway (1967, 1968) synthesized the channels and representations issues in a critical analysis of media research and theorizing. The substantive issue for Conway was

> the apparent confusion between "modalities" and "channels." That is, there is no consistent distinction drawn between the sensory modality involved in the communication of information and the coding system which characterizes the information presentation.
>
> The failure to make necessary conceptual distinctions not only leads to ambiguous treatment comparisons both within and across separate studies, but it seems also to have blinded researchers to the existence of significant presentational conditions [Conway, 1967, p. 377].

Conway then proceeded to use Knowlton's concept of iconic and digital sign types to explicate his criticism of Hartman's, Travers' and Severin's experimental design and conclusions, as well as their theorizing.

Conway viewed the so-called multiple-channel presentations as rather specific combinations of sign types and channels. The studies of Van Mondfrans and Travers and Severin were shown to be based upon only one of several possible research paradigms, a paradigm in which the sign types (representations) were constant while the number and nature of the channels were varied. Therefore, Conway deduced, that although those studies had consistently demonstrated that in learning meaningful material there was no advantage in using a two-channel over a one-channel presentation when the sign types remained the same, the question of whether a presentation combining two sign types is more efficient than using either one of the sign types alone remained unanswered.

Conway concluded that

> the crucial issue . . . is the failure to recognize and make explicit the built-in assumptions about sign learning which underlie certain operational procedures manifestly adopted to distinguish between pictorial and verbal stimuli [Conway, 1967, pp. 382-383].

Media Selection and Design

Numerous attempts have been made in the past 15 years to formulate taxonomies and strategies for the selection and design of instructional media. Miller et al. (1957) organized a series of principles for learning from motion pictures based upon his drive-cue-response-reward theory of learning. Allen (1967) generalized the findings of media research in a matrix which put nine media on one dimension, six learning objectives on the other dimension, and effectiveness ratings of high, medium, and low in the cells. May (1968) proposed a selection strategy based upon two major categories of desired outcomes, reproductive tasks, and productive-constructive tasks.

Perhaps the most involved attempts to formulate media design and selection strategies are those of Briggs, Campeau, Gagné, and May (1967), Briggs (1970), Bretz (1971), and Tosti and Ball (1969). Briggs et al. suggested a six-step procedure for the design of multimedia instruction. The weakness of their procedure resided in those steps which depend upon specification and selection of possible media options based, ultimately, on the intuitive competence of the designer rather than on a critical methodology. Briggs' Handbook (1970) improved some of this fault by incorporating a selection matrix and strategies similar to those of Allen and May. Bretz identified eleven functions for communication in instruction, the selection of the appropriate media for each of them being based upon such media variables as visual presentation, audio presentation motion, and abstraction of subject matter.

Most closely related to this study is a media design system by Tosti and Ball which differentiates the concepts of media and presentations. For them, the presentation is the form structures the instructional event whereas the media are merely the means of delivery of the presentation. Therefore, presentations are designed, not media. They asserted that in order to select media which best fit the presentation requirements, "Media selection must be done in terms of eliminating media which limit or otherwise adversely affect the presentation design rather than specifying advantageous media [Tosti & Ball, 1969, p. 8]." Their behavioristic approach to presentation design included six dimensions: (1) stimulus, (2) encoding form and duration, (3) response-demand form, (4) demand frequency, (5) management form, and (6) frequency. The levels of the stimulus encoding (representation) dimension included verbal, symbolic, pictorial, and environmental structure, with verbal acknowledged as a subset of symbolic.

Review of Related Research

Nearly all previous media research relates only obliquely to the principal concerns of this study. Most of the research has been conducted with high school, college, and military subjects rather than with elementary school children. Furthermore, there is a dearth of media research in the domain of independent learning. Actually, only the exploratory study by Nielsen (1970) has directly engaged with the major

problem of this study: the design, production, and testing, under controlled conditions, of various multimedia treatments to provide evidence concerning the relationships among representation modes, presentation media, and age levels when media is used in independent learning settings in elementary schools.

Audio and print presentations. Until the study by Nielsen, there had been no media research which investigated audio tape and booklet versions of filmloop or filmstrip lessons. This may be a result of the fact that most media research investigating audio and print media has been conducted with groups of subjects, requiring the fixed pace of audio presentations with such large-group presentations as projected slides and motion pictures.

Hartman (1961) in reviewing early research on the comparative effectiveness of audio and visual channels reported that, for meaningful words, eight studies favored print, three favored audio, and four found no significant differences. In studies with meaningful prose, Hartman reported eleven favoring audio, nine print, and three with no significant differences. He noted that all the studies supporting audio were with young children, while all those favoring print were with adults, leading him to conclude that "the print channel is more effective than the audio when the information to be presented is difficult or complex and the subjects are reasonably literate [Hartman, 1961, p. 254]."

Although no previous research relates directly to the present study, a number of past studies have some relevance to it. Ericksen and King (1917) and Russell (1938) reported the interaction of media with age, the auditory medium being more effective than the print medium for relatively young children (grades 3-5) with the advantage shifting to the print medium as age increased. Cooper and Gaeth (1967) found a contrary interaction when they investigated learning of nouns with a paired-associate paradigm: the print presentation (using slides) was superior to audio for early grades (4-6) while the audio tape presentation was superior for the later grades (10 and 12). The investigators, noting this unexpected result, suggested that at some point in language development there ceases to be an inherently preferred modality for materials which are highly meaningful.

Chang (1969) investigated the ability of sixth-grade pupils to use verbal context clues in listening and reading. Of six categories of clues, the visual mode was favored in three. Males low in reading ability achieved better in category definitions and descriptions using the aural mode.

Hsia (1969) reported the results of a study in which audio (A), visual (V), and audiovisual (AV) presentations of verbal material were used with seventh grade subjects. Investigating the interactions of A, V, and AV with low and high IQ, Hsia noted that when information recalled was the criterion, A and V presentations resulted in significant

differences in performance between IQ groups, but that the AV presentation of the poetry verses resulted in no significant differences between IQ groups. Other differences were noted for output, error, and equivocation measures.

Levonian (1968) demonstrated that for high school subjects viewing a traffic safety film, the relation between arousal (as measured by galvanic skin response) and delayed retention of information was virtually the same for information presented aurally and visually.

Finally, Nielsen (1970) found no meaningful differences in the effectiveness of audio tape and booklet as media presenting the verbal component of a filmstrip lesson and no significant interactions of this presentation variable with age. Contrary to Hsia's findings (1968) that the visual channel was more dependable but the audio channel was more efficient, Nielsen found the booklet more efficient than the audio tape as the presentation medium. He concluded that the results suggest that criteria other than effectiveness (efficiency, for instance) may be considered in the selection of the medium by which the verbal component of filmstrip lessons is to be presented in independent learning settings.

Still and motion presentations. As reported by Allen and Weintraub (1968) no intensive study has been conducted to identify the differential effects of motion and still pictorial presentations. Hoban and van Ormer (1950), in reviewing early film research, reported few differences in learning when still and motion treatments were compared in a variety of studies. In his review of media research, Allen (1960) concluded that one mode of presentation was about as effective as the other.

Miller (1957) in a two channels study compared motion picture film with still picture film. Even though the subject matter (breaking a wild horse) selected in this study seemed to favor the motion variable, no significant differences were found. Allen, Filep, and Cooney (1967) found similar results in their study. In spite of the inherent movement nature of the selected subject matter, the printed-verbal group performed slightly better than the pictorial presentation groups.

In another related study, Allen, Cooney and Weintraub (1968) investigated the effectiveness of five different modes of audio-narration in combination with motion picture and still slides. Considering the visual presentation variables, they found no significant differences. In terms of attitude toward the presentation modes, there was an indication, though, that motion sound films were perceived more positively than still slides presentation.

Allen and Weintraub (1968) investigated the motion variable upon the learning of cognitive information. The study was conducted to determine the appropriativeness of motion in communicating cognitive information. Three film modes were studied: motion pictures, sequenced

still pictures, and single still pictures. They found that the motion picture mode of presentation was superior to the other two still picture modes regardless of subject matter content and objectives, the grade level of the subjects, or the sex of the students.

Houser, Houser and Mondfrans (1970) conducted an experiment in which still slides and motion pictures were used to teach two concepts; one involving movement, the other characterized by non-motion attribute. They found that whatever the motion or the non-motion nature of the concepts taught, the motion picture mode of presentation is significantly superior as a learning device.

Finally, Allen, Daehling, Russell, and Nielsen (1970) reported no significant differences between still and motion treatments in their study designed to investigate seven visual-verbal presentations. When sound motion picture, silent motion picture, sound still picture, silent still picture; sound print, print only, and sound only presentations were compared, both sound motion picture and sound still pictorial presentations proved to be superior to all other presentations.

Verbal and Pictorial Modes

The relative effectiveness of verbal and pictorial modes of representing various types of concepts and principles has often been studied.

The effects of photographs and words at different levels of abstraction were studied by Long and Welch (1942). They found that children's ability to apply a principle of reasoning was adversely affected by the verbal mode and by high levels of abstraction, but that the difficulty decreased with age. Kurtz and Hovland (1953) presented evidence that elementary school children who circled and recited work responses performed significantly better on recall and retention tests one week later than did similar children who circled matching pictures.

Several investigations have revealed differential effects of verbalization and pictorial perception. Toch and MacLean (1962) reported a finding obtained by the Norwegian psychologist Rommetveit. In an experiment involving concept formation by children, Rommetveit found that verbalized concepts inhibited perception of relevant dimensions of the problems. McConnell (1962), investigating concept learning in nursery-school and second-grade children, found that by arranging objects in a certain pattern perceptual mediation effects could be achieved in young children which were similar to those obtained by verbal means in older children.

In a study of the effect of mental ability and mode of representation on the way tenth-grade students structure information, Donald (1968) found that mode did not have a significant effect upon proficiency of concept learning, nor did it affect the structuring process. Lombrozo (1969) determined that fourth- and tenth-grade minority-group

pupils evidenced higher cognitive abilities in response to words than to pictures. In addition, she observed that more abstract and descriptive responses were given to the verbal mode while more functional responses were given with the pictorial mode.

Associative studies demonstrating differential responses elicited by pictorial and verbal stimuli are numerous (Lumsdaine, 1949; Herman, Broussard, & Todd, 1951; Kopstein & Roshal, 1961; Deno, 1965; and Jenkins, 1968). Lumsdaine (1949) and Kopstein and Roshal (1954) found that in paired-associate learning the use of pictures to represent the stimuli was superior to the use of printed words; whereas words were superior to pictures for the responses. Otto (1962, 1964) found in a series of studies that pictures of objects and word-names of them did not elicit the same responses. He suggested that, to the contrary, "pictures may in fact present clues that tend to detract from or to contradict verbal descriptions [Otto, 1964, pp. 246-247]." Bourisseau, Davis, and Yamamoto (1965), replicating Otto's study, confirmed his findings.

Severin (1967), in a test of cue summation theory with junior high school students, found a presentation of audio with related pictures to be superior to one with audio and print, while audio with print was not significantly better than print alone. The effectiveness of a presentation with print and related pictures was not investigated.

The findings of a study by Allen, Filep, and Cooney (1967) suggested that the effectiveness of the visual mode (print-verbal, still-graphic supplementation, or motion picture supplementation) was relative to the inherent concreteness or abstraction of the subject matter. That is, when the subject matter concepts to be learned had concrete-referents, an audio-pictorial presentation was superior to an audio-print (redundant) presentation; but when the concepts were abstract, there was no advantage to an audio-pictorial presentation.

Jenkins, Stack and Deno (1969) attempted to determine whether recall and recognition of pictures of common objects were more accurate than recall and recognition of words. Simple line drawings and words were presented to second-grade pupils by means of projected 35mm slides. No significant difference in the number of items recalled was observed for words and pictures. Recall performance, requiring listing of labels describing pictures recalled, was significantly related to reading level, but there was no interaction with mode. For recognition performance, involving correct identification of originally presented pictures and words, pictures were superior to words. For recognition, neither was reading level related nor was there any interaction of reading level with mode. Jenkins concluded that if children tend not to label a picture--as suggested by Ducharme and Fraisse (1965)--that fact would probably account for their inferior performance on recall tasks which required listing labels describing the pictures recalled.

Allen and Daehling (1968) investigated the effects of figural, symbolic and semantic (verbal) modes of visual representation in three related experiments. In each experiment a different general science

subject area with either figural, symbolic, or semantic inherency was selected for learning of factual information by sixth-grade pupils. Only the semantic mode was statistically superior in the experiment with the figurally inherent subject matter. No significant differences were found in the other two experiments. The investigators did find that "the language ability factors of the subjects were significantly related to test performance, but were unrelated to the mode of visual presentation used [Allen & Daehling, 1968]."

Finally, in Nielsen's study (1970) no meaningful differences in the general effectiveness of iconic and symbolic modes of representation were found, but the hypothesized interaction of modes with age was found. It was concluded that when a verbal-type test is the measure of learning, the iconic mode of representation may be superior but only for nine-year-olds. As in studies by Zankov (Mialaret, 1966), Beilin et al. (1968), and Allen et al. (1967), an iconic, directive mode of the verbal component is effective with young learners.

Directing attention and posing questions. Some of the research on the direction of attention and posing of questions has a bearing on the modes variable and the design of the iconic and symbolic treatments in this study.

McGuire (1961), investigating the effects of descriptive narration in a demonstration film, observed that attention-directing narration facilitated performance on features to which attention was directed, but debilitated performance on that to which attention was not directed.

Allen, Filep, and Cooney (1967) studied the effectiveness of combinations of three visual and three audio modes with three types of subject matter for eighth-grade students. The findings indicated the directive mode of audio presentation, which pointed out relevant cues in the print and pictorial presentations, was superior to silent and redundant (repeating the printed material) modes for the still-graphic and print-verbal presentations; but the directive mode was inferior to the motion-picture presentation.

Zuckerman (1949) studied modes of film narration and concluded that the imperative instructions were superior to passive-voice descriptions of the steps in the task being demonstrated. Thompson (1944) in a study reported by May and Lumsdaine (1958) found that guided verbalization of steps in an assembly task was found to facilitate performance if relevant but hinder if irrelevant.

Zankov (Mialaret, 1966) reported both qualitative and quantitative differences in responses of fifth-year pupils to two modes of instruction. For the mode by which oral teaching directed attention rather than presented knowledge, correct replies were nearly four times as frequent as no reply. For the mode by which oral teaching presented knowledge, no replies were more frequent than correct replies. The attention-directing mode included 19 times as many correct replies as

incorrect replies, while the knowledge-presenting mode induced only 4 times as many correct as incorrect replies.

Contradictory findings have been reported by those investigating the insertion of rhetorical questions in instructional media. Lumsdaine, May, and Hadsell (1958) inserted pupil participation questions and correct answers in a film on the heart and circulation, increasing learning significantly. May and Lumsdaine (1958) demonstrated that "thought-provoking" rhetorical questions spliced into an existing film improved learning. Maccoby, Michael, and Levine (1961) found practice questions preceding expository sections to be less effective than those following.

Butts (1956), Kantor (1960), Gilpin (1962), and Vuke (1962) each found evidence to the contrary. Butts investigated the effectiveness of declarative, interrogative, and imperative captions on still slides and found declarative and imperative captions superior to interrogative captions. Kantor inserted eight questions in two copies of a film about sunfish--in one the questions appeared before the related content, in the other, after the content. A third film had no questions inserted. The results of the experiment indicated that the tenth-grade subjects learned equally well from all three versions of the film, i.e., the inserted questions had no effect on learning. Vuke also studied inserted questions in an existing film on experimentation. Eighteen questions were inserted in the experimental film, lengthening it by one and one-half minutes. The control film remained unchanged. Each film produced significant gains, but there were no significant differences between the two films on the posttest or retention test. Filpin compared rhetorical question and direct statement treatments of programed materials for first- and third-grade pupils. A tape-slide presentation was shown to groups of 15 subjects. On the criterion test no significant differences were noted.

Finally, several studies have provided support for Rothkopf's mathemagenic hypothesis (1966) which suggested that test-like events generally had a facilitating effect in learning from written material. Frase (1968) confirmed Rothkopf's earlier findings that questions following a passage were superior to questions preceding a passage in facilitation of learning. Furthermore, an interaction of frequency of questions with position was significant, with questions appearing after every paragraph the most effective treatment. Bruning (1968) showed that the performance of college students given test-type review items inserted within the text of a 1500-word passage was superior to the performance of those students given an identical test with the review items in declarative sentence form.

CHAPTER TWO

DESIGN AND METHODOLOGY

This chapter presents a description of the experimental design, variables and materials, the measurement instruments and dependent variables, the experimental populations, the experimental and data processing procedures, and the statistics employed in this study.

Experimental Design

The study consisted of four separate but related 2x2x2 experiments for which eight different media treatments were prepared and used in various combinations in the four experiments (see Figures 2-1 and 2-2).

A three-factor ANOVA design with six replications, based upon Campbell and Stanley's Posttest Only Design #6 (1963, pp. 25-27) was developed. The original design was modified, eliminating the control group.

Experimental and Organismic Variables

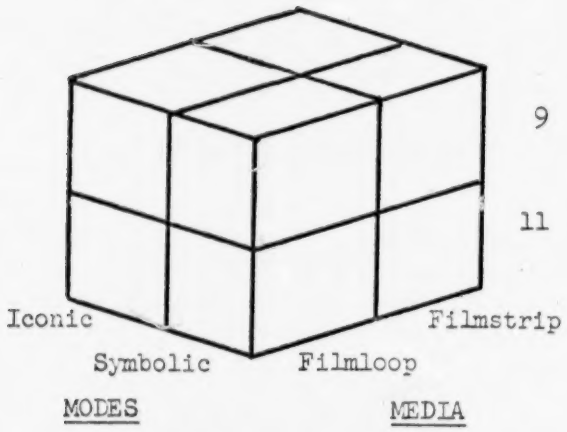
The effects of three experimental variables and the interactions of those variables with one another and with one organismic variable, Age, were investigated in this study.

Modes of Representation Variable

During the middle and closing elementary years two modes of cognitive representation have been hypothesized as dominating the young learner's thinking. The middle years are seen as dominated by the iconic mode while the closing years are seen as the period when the symbolic mode begins to be the dominant mode of cognitive functioning.

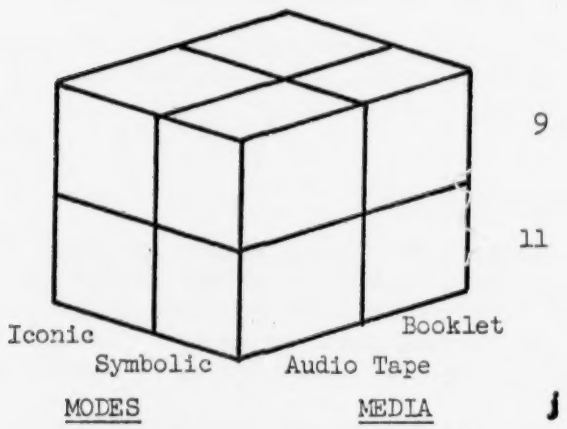
To investigate the effects and interactions with Age of the Mode of representation variable in instructional materials, two treatment modes were designed and used.

Iconic mode. One half of the experimental treatments produced used the Iconic mode of representation. With the Iconic treatments, either filmstrip or filmloop images were the principal means of representing the concepts in the instructional materials. The verbal component of this mode, which directed the S's inspection of the images,



Medium Presenting Verbal Component	
in	is
Experiment #1	Audio Tape
Experiment #2	Booklet

Figure 2-1. Design of Experiments One and Two



Medium Presenting Pictorial Component	
in	is
Experiment #3	Filmloop
Experiment #4	Filmstrip

Figure 2-2. Design of Experiments Three and Four

was composed essentially of two types of sentences, imperative and interrogative. The imperative directed the S to observe, compare, or otherwise perceive objects, events, or features presented by the filmstrip or filmloops. The interrogatives posed questions for which answers could be realized (though not necessarily verbalized) from an inspection of the current images or a reflection upon preceding images and guidance.

Symbolic mode. The remaining half of the experimental treatments produced used the Symbolic mode of representation. With the Symbolic treatments, verbal descriptions and statements of rules and principles in combination with either filmstrip or filmloop images were the principal means of representing the concepts in the instructional materials. The verbal component was composed essentially of declarative sentences describing the objects and events presented by the filmstrip or filmloops and formalizing the conceptual rules and principles relative to the images.

Media Variables

Frequently a number of media are available in a variety of combinations for the presentation of instructions, guidance, pictures and drawings, tables and figures, graphics, and other types of conceptual content. Various conditions and purposes are met and served by various strategies for selecting and combining media. Media, media strategies, and other techniques which result in different multimedia components, systems, or packages of instructional materials are conceived of as media presentation variables.

In two experiments, the effects and interactions of media presenting the pictorial component of instruction were investigated. In the remaining two experiments the effects and interactions of media presenting the verbal component of instruction were investigated.

Pictorial Presentation Variable

Two media for presentation of pictorial components were selected for investigation in Experiments One and Two. [In Experiment One an audio tape presented the verbal component while in Experiment Two a booklet presented the verbal component.]

Filmloop. Super 8mm color motion pictures in Technicolor cartridges presented photographic images of real objects and events and graphics in half of the experimental treatments.

Filmstrip. A 35mm color filmstrip presented still photographic images of real objects and events and graphics in the remaining half of the experimental treatments.

Verbal Presentation Variable

Two media for presentation of verbal components were selected for investigation in Experiments Three and Four. [In Experiment Three filmloops presented the pictorial component while in Experiment Four a filmstrip presented the pictorial component.]

Audio tape. Cassette tape recordings were used to mediate a teacher presenting objectives, content, and guidance for half of the experimental treatments.

Booklet. Booklets with pages of typed copy xerographically enlarged and reproduced were used to present objectives, content, and guidance for the remaining half of the experimental treatments.

Organismic Variable

Two age levels assumed to represent differing levels of cognitive functioning were selected in order to determine the possible congruence of modes of representation and functioning as well as to determine possible differential effects of the four media used in the experimental treatments.

Age nine. Age nine was selected as representing the period of dominance of the iconic mode of cognitive functioning. Half of the subjects in each experiment were plus or minus four months of being nine years of age.

Age eleven. Age eleven was selected as representing the period of emergence of the symbolic mode of cognitive functioning. Half of the subjects in each experiment were plus or minus four months of being eleven years old.

Experimental Materials

Eight experimental, multimedia treatments were produced for the study, although only four treatments were used in any single experiment. Table 2-1 presents the media and modes combinations of each of the eight multimedia treatments. Table 2-2 identifies the four treatments used in each of the four experiments.

Content

The subject matter content of every treatment was the same; motion picture animation with flipcards. This content had been origi-

TABLE 2-1

EIGHT EXPERIMENTAL MULTIMEDIA TREATMENTS

	MODES	
MEDIA	Iconic	Symbolic
Filmloops & Audio Tape	1	2
Filmloops & Booklets	3	4
Filmstrip & Audio Tape	5	6
Filmstrip & Booklet	7	8

TABLE 2-2

TREATMENTS USED IN EACH EXPERIMENT

	Treatments
Experiment One	1,2,5,6
Experiment Two	3,4,7,8
Experiment Three	1,2,3,4
Experiment Four	5,6,7,8

nally developed and used by Nielsen (1970) and was revised in accordance with recommendations based upon the results of his exploratory study.

The concepts represented iconically or symbolically in the experimental treatments included the following: (1) seriation of images, (2) static image elements, (3) transient image elements, (4) reversibility of planned action, and (5) quantumization of an action into a series of still images.

Instructional Objectives

By the end of a multimedia lesson on flipcard animation, each subject was to be able to: (1) identify parts of a picture which are static from flipcard to flipcard and parts of the picture which are transient from flipcard to flipcard; (2) identify the gradual difference of the transient elements of the image from flipcard to flipcard; (3) identify three conditions necessary to simulate an action with a set of cards; (4) looking at different positions of the transient elements the subjects will identify the direction of the action; (5) looking at different positions of the transient elements the subjects will situate the moving object in relation to the starting, middle and ending points of the action; (6) looking at different cards of a set he will locate where these cards are situated in the set of flipcards; (6) rearrange the cards in such a way that the action happens backwards; (8) identify the perceived position of the viewer in a standing still animation situation; (9) identify the perceived position of the viewer in a moving along animation situation; (10) identify which element of the image is transient and which element is static in a standing still kind of animation; (11) identify which element of the image is transient and which element of the image is static in a moving along kind of animation; (12) differentiate between a standing still and moving along kind of animation; (13) hold correctly a set of cards in order to flip them; (14) flip correctly a set of cards.

Flipcards

Fifteen different sets of flipcards from the original 21 used in Nielsen's study were used in this investigation. They were used (1) in the production of filmloops and filmstrips, (2) in the production of test materials, and (3) as test instruments. Table 2-3 presents descriptions and uses of the flipcard sets.

Each set was composed of from 18 to 42 flipcards nominally 2.5" x 4.25". An animated line-drawing appeared on the lower half of each flipcard. Picture backgrounds and the object appearing to move were drawn on separate animation cells. By repositioning either the object or the background and photographing the composite picture on high-contrast film with a single-frame camera, it was possible to produce a negative with a single frame for each flipcard drawing in a set. Each frame was enlarged to the finished size on double-weight, photo-

TABLE 2-3

DESCRIPTIONS AND USES OF FLIPCARD SETS

Action Animated	Type of Animation	Use
Balloonist descending	SS, MA	O
Ball rolling between tanks	SS, MA	X
Big fish chasing little fish	SS	
Boy hopping on pogo stick	MA	O
Ice truck driving away	MA	X O
Man riding bicycle	SS	X O
Moon rising behind castle	SS	X
Seashores do-si-doing	SS	O
Ship sailing to a castle	SS	X O
Sub moving under water	SS	O
	MA	X
Sub sinking to sea bottom	MA	X O
Villain learing	SS	O

SS = Standing Still

MA = Moving Along

X = Treatment

O = Measuring Instruments

graphic paper. Where more than one copy of a set was needed, the photo-enlarged flipcards were reproduced by offset printing on heavy index card stock and trimmed to size.

Fourteen flipcard sets had animated pictures with objects which changed position from drawing to drawing within the "frame" of the picture. The effect was as if one were standing still in one place, watching the object move by (Type SS). Seven flipcard sets showed an animated object in the center of each picture "frame"; the background changed position from drawing to drawing. The effect was as if one were moving along with the animated object (Type MA) (Nielsen, 1970, pp. 69-70).

Booklets

Four booklet versions were produced for use in four of the multimedia treatments. Two symbolic booklets were produced; the only difference between them being the instructions given for use of either the filmstrip or the filmloops. In a like manner, two iconic booklets were produced, differing only in the instructions given for their use with the filmstrip or filmloops.

Each of the 49 frames in a booklet was numbered to correspond to the number of each filmloop sequence or filmstrip frame. The booklets were made of bound, 8" x 5" Xeroxed pages reproduced from typed copy enlarged 140 percent with a Xerox camera. (A reproduction of a page from one of the booklets used in the experiments is presented in Appendix C.)

Audio Tapes

Four audio tapes were produced for use in four of the multimedia treatments. Except for the introductory instructions on the use of the use of the audio tape with either the filmloops or the filmstrip, the audio tapes were the same as the booklets: Two were iconic versions, while two were symbolic versions.

Recordings for each audio tape were transferred from quarter-inch master recordings to cassettes. An adult female narrated all the audio tapes produced. (Scripts of the audio tapes are included in Appendix A.)

Filmloops

The motion-pictorial component of half of the experimental treatments consisted of three super 8mm color filmloops. A total of 49 motion picture sequences of children using flipcards, graphic displays of flipcards, titles, instructional objectives, and sequence numbers had a running time of fourteen minutes. The 49 sequences matched the

49 frames in the booklets and the 49 tape sequences. The finished films were duplicated on Kodachrome II film by Eastman Kodak Company and packaged in three super 8mm Magi-Cartridges by Technicolor.

Non-experimental subjects were involved in the development and revision of filmloop and filmstrip presentations.

Filmstrip

The still-pictorial component of the remaining half of the experimental treatments consisted of a 49-frame color filmstrip. The filmstrip, a still version of the filmloops, was produced after a selection of appropriate scenes from the filmloop footage. The 49 frames matched the 49 booklet frames and tape sequences. The images presented by the filmstrip conformed in every detail to the filmloop images. All photographs used were photographed originally on 35mm color film and reproduced in filmstrip format using an Olympus Pen-F single-frame camera with a Micro-Nikkor lens. The finished filmstrip, printed on Eastman Color film, was duplicated and packaged by R.G.B. Color Laboratory.

Multimedia Packaging

In each of the four experiments, four experimental treatments were assembled into multimedia packages, each containing (1) instruction sheets, (2) filmloops or filmstrip, (3) audio cassette or booklet, (4) test materials, and (5) pencils.

Measurement Instruments

The same written and performance tests were used in each of the four experiments. The written test consisted of eight verbal-type multiple-choice items and seven pictorial-type multiple-choice items. A test to measure transfer of learning was also used, consisting of six performance items. The combined group of 21 items was considered one test while each type-group was considered a subtest. All but one of the verbal-type items were matched with equivalent pictorial-type items; that item was matched with an equivalent performance item. (Appendix B presents reproductions of the written test and the performance test checklist.)

All tests and test items were developed in thorough tryout-revise-tryout cycles. Item analysis and Kuder-Richardson Formula 20 statistics were used to evaluate items and to estimate the reliability of the subtests and total test (Guilford, 1965). Table 2-4 presents descriptive statistics on the final tryout.

In order to standardize the administration of the written test, all subjects read directions explaining how to proceed. They also answered two practice questions which gave them an opportunity to familiar-

TABLE 2-4

DESCRIPTIVE STATISTICS FOR THE FINAL TRYOUT

Test	No. of Items	Mean	S.D.	S.E.	Reliability (K-R #20)
Performance test	6	2.56	1.54	0.36	0.52
Iconic test	7	3.73	1.40	0.33	0.20
Symbolic test	8	4.78	2.10	0.49	0.70
Total test	21	11.71	3.46	0.82	0.64

ize themselves with the format of the items. To reduce problems relating to the manipulation of testing materials by the subjects, answers were recorded directly in the test booklet. The same experimenter throughout each experiment administered the performance test, marking the performance checklist.

Dependent Variables

Seven dependent variables were analyzed for each experiment. They included (1-3) the three subtest scores, (4) the total score, (5) the time-to-completion (in minutes) for the experimental treatment, (6) the objective test (verbal and pictorial subtests), and (7) the total time (treatment and testing time).

Experimental Populations

In all four experiments, 9- and 11-year-old pupils from grades three through six were randomly selected and assigned to the experimental treatments. Forty-seven subjects were included in the final analyses in each of the first two experiments, while forty-eight were included in the final analyses in each of the remaining two experiments. Educable and trainable mentally retarded pupils were excluded from the populations sampled.

The populations for Experiments One and Three were from the same elementary school in the Fountain Valley School District, Fountain Valley, California. The populations for Experiments Two and Four were from the same elementary school in the ABC School District, Cerritos, California.

Two prime factors determined the selection of these schools: one was that independent study was a routine practice; the second was that only minor adaptations to school schedules, facilities, or study activities would be required.

Facilities and Equipment

In Experiments One and Three each experiment was conducted in a vacant classroom assigned for independent study. In Experiments Two and Four each was conducted in the school's learning center, an extension of several classrooms serving as a teaching, independent study, and resource area.

Six learning stations were used throughout each experiment. Tables and chairs in the classroom and learning center were arranged to form the stations. The light level at each station was appropriate for the multimedia package being used at it. Table 2-5 presents the distribution of the media and equipment among the six stations for each of the four experiments.

TABLE 2-5

DISTRIBUTION OF MEDIA AND EQUIPMENT IN EACH EXPERIMENT

Experiment	Total No. of Stations	Number of Learning Stations with Media & Equipment			
		Tape Recorder	Booklet	Filmloops & Projector	Filmstrip & Projector
One	6	---	6	3	3
Two	6	6	---	3	3
Three	6	3	3	6	---
Four	6	3	3	---	6

Equipment exactly the same as that regularly used by the pupils was used in each experiment. The intent was to decrease the effects of unfamiliarity and novelty associated with the introduction of new equipment and, thereby, to increase the external validity of the results.

The equipment used included Graflex filmstrip projectors with 3-inch lenses, Technicolor super 8mm filmloop projectors, Panasonic cassette tape recorders, and Delux headsets. The image size for the super 8mm filmloops was 13" x 10", while the filmstrip image size was 17" x 11". In both instances the images were projected onto small screens positioned 48" from the projectors.

Conduct of the Experiments

In general, in each experiment the experimental procedures and events were essentially the same.

Prior to conducting each experiment, a conference was held with the staff at each school at a regular faculty meeting. The nature of the study and the involvement of the teachers was explained. There was no discussion of the specific content in order to avoid the possibility of familiarizing the populations with the content.

One week prior to the first experiment, a trial session was conducted with three 9-year-old and three 11-year-old pupils. The objective of this trial session was to check out the materials and procedures to be used in the experiments.

Experimental Events

Each morning assignment cards were delivered to the teachers of pupils involved in the day's experiment. Teachers distributed the cards to the pupils several minutes before they were to come to the classroom or learning center. Cards for absent pupils were returned by the teachers and alternates were selected by the experimenter.

Each S was scheduled for a single multimedia package which included the experimental treatment and tests. A S came from his regular classroom or learning center activity at a predetermined time (indicated on his assignment card) and returned to it upon completion of his participation in the experiment.

Three experimental sessions were started each day of an experiment. Individual starting times during each session were staggered--the first three Ss reporting five minutes earlier than the second three--in order that the three Es might greet and start each S individually.

As a S reported to the classroom or learning center, one of three Es greeted him and directed him to the appropriate learning sta-

tion. The S was then instructed how to operate the equipment. (This was basically familiarization, as most Ss had used the equipment before.) The E then interacted with the S to confirm that he understood the signals and symbols that coordinated the media. A printed sheet in extra large type explained these symbols.

The first four frames of each treatment were practice frames and reinforced the procedures. The E made sure that the S was maintaining coordination between booklet or tape and filmloop or filmstrip.

When the S started frame or sequence #5, the E recorded the starting time on the S's card. At the end of the lesson the S raised his hand and the E recorded the ending time.

The E then removed the written test from the multimedia package and instructed the S to read the directions, answer the two sample questions, and then to raise his hand. After the S raised his hand, the E checked the sample questions to confirm that the S understood the test procedures. When the E felt that the S understood, the S was instructed to begin the test and the E recorded the starting time on the S's card.

As soon as the S completed the test, he raised his hand according to instructions printed at the end of the written test. An E recorded the finishing time and then brought five sets of flipcards to the station, recording the starting time for the performance test. The E read directly from the performance checklist (Appendix B) while the S demonstrated his answers physically and verbally. The E recorded the correctness of each response on the checklist. When the final item had been answered, the finishing time was recorded by the E on the S's card. The same E administered the performance test for each S throughout an experiment.

Upon completion of the performance test the S was told that the experiment was being conducted to find out better ways of making instructional materials. He was then asked to cooperate by not talking about what he had learned until after the experiment was finished at the school, thanked for his cooperation, and instructed to return to his regular assignment.

Statistics

Power and the Null Hypothesis

In this study, two types of findings were hypothesized: significant differences or interactions and no significant differences. All but General Hypothesis 1.0 hypothesized significant differences or significant interactions. For such hypotheses, nulls are tested employing statistics which guard against alpha (α) or type I errors--the probability of rejecting the null when it is actually true.

However, if as with General Hypothesis 1.0 no significant dif-

ferences are predicted, then the research hypothesis assumes the conventional null form. The problem then becomes one of guarding against beta (β) or type II errors--the probability of accepting the null hypothesis when it is actually false.

A test of the power ($1 - \beta$) of a statistical test then becomes crucial in analyses of such results. The process of determining power is complex, involving five variables; the alpha error rate, the number of treatments, the sample size, the population error variance, and the smallest difference between treatment means considered to be of practical significance, i.e., the "smallest meaningful difference" (SMD) to be detected at the beta significance level. For General Hypothesis 1.0 a power approach developed by Nielsen (1970) was used to determine the beta error rate and the confidence level in retaining the null hypothesis.

Since the power of a test indicates the probability of detecting a meaningful difference if one really exists, the power approach was also employed in the analyses and interpretations of data for other hypotheses. Given the knowledge that he knows, with some certainty, that no practical, meaningful differences exist between contrasting treatments, the designer of instructional media and events is given freedom to chose between them on the basis of some other factor, such as cost of development, replicability, ease of use, or efficiency.

Statistics Employed

Each of the dependent variables was analyzed employing the general linear hypothesis model and the F statistic. For pre-planned comparisons the t statistic was employed (Kirk, 1968).

For estimates of the power of ANOVA tests, equations provided by Kirk were used (1968, pp. 178-179). The smallest meaningful differences (SMD) were defined in terms of standard deviations (.80 SD and 1.00 SD) as proposed by Nielsen (1970, pp. 88-90).

Significance Levels

In an exploratory study such as this, it is important not to cut off a promising line of research by guarding too severely against type I or type II decision errors (Kirk, 1969). For the purposes of this study, the .05 significance level was considered to be less desirable than the .10 level. The reasoning was twofold: First, in an exploratory study, before refinement of measurement instruments and experimental procedures, errors of measurement and other factors affecting the population error variance could make the error term in the statistical tests relatively large. Second, in independent learning settings, individual learner variables are more likely to obtain those conditions for their maximum expression. Consequently, the error terms could be relatively large. In either event, the probability of detect-

ing a meaningful difference would be materially reduced. Therefore, the .10 significance level was considered to be appropriate and adopted for the tests of the hypotheses in this study.

Data Processing

Pre- and post-experiment data processing included gathering and coding of descriptive data, collection of test answers, and time data, transfer of data to keypunch coding forms, keypunching and verification of data, scoring of test items, and statistical analyses of the experimental data.

The USC Computer Science Center facilities and electronic calculators in the Department of Instructional Technology were used to process all data. All statistical programs were run on the Center's IBM 360/65 computer. Biomedical Computer Program BMDX64 (Dixon, 1969), applying the general linear hypothesis model, was used for all analyses of variance.

The special program developed by Nielsen (1970) to compute beta and power for different levels of alpha and for different values of the "smallest meaningful difference" (SMD), was also used. The program features a subroutine for making tests of difference between means using the IBM Scientific Subroutine Package TTest, and also contains a subroutine for making F tests of differences in standard deviations.

Another program, developed by Young Lee was used to compute the KR #20 statistic.

Research Hypotheses Investigated

For each of the four experiments in this study, specific research hypotheses were derived from four general hypotheses.

As suggested by Nielsen (1970), Siegel and Siegel (1968), and Salomon and Snow (1968), and by the results of past media research, significant differences in effectiveness might be expected to be found more frequently in the interactions of variables rather than in their main effects. Consequently two general hypotheses relative to effectiveness were applied and tested in each of the four experiments.

General Hypothesis 1.0

As measured by the dependent variables for effectiveness, no significant differences in mean scores will be found for the Media and Modes variables for the populations sampled.

General Hypothesis 2.0

As measured by the dependent variables for effectiveness, significant differential effects upon mean scores will be found in the interactions of Media, Modes, and Ages for the populations sampled.

Two general hypotheses relative to efficiency were applied and tested in each experiment.

General Hypothesis 3.0

As measured by the dependent variables for efficiency, significant differences in mean scores will be found for the Media Variable for the population sampled.

General Hypothesis 4.0

As measured by the dependent variables for efficiency, significant differential effects upon mean scores will be found in the interactions of Media, Modes, and Ages for the populations sampled.

CHAPTER III

RESULTS

In this study statistical analyses were completed separately, by experiment. However, since some hypotheses were tested in more than one experiment, the results will be presented grouped by hypotheses rather than by experiment.

Hypotheses of No Significant Differences

Three specific hypotheses were derived from General Hypothesis 1.0. Each related to the expectation that no significant differences in effectiveness would be found when the main effects of the presentation media or the representatic modes were analyzed. The results of factorial ANOVA for hypotheses are presented in Appendix D and are summarized in Tables 3-1 and 3-2. Tables 3-3, 3-4, and 3-5 present the results of pre-planned contrasts of pictorial media, of verbal media, and of modes. Values for the t tests, smallest meaningful differences (SMD) and results of two-tailed tests of significance appear for each of the dependent variables for effectiveness. The power of the statistical tests was greater than .99, i.e., the probability of finding a difference equal to or greater than the SMD if one truly existed, was greater than .99.

Hypothesis 1.1

> As measured by the dependent variables for effectiveness, no significant differences in mean scores will be found between Filmloop and Filmstrip media for the populations sampled.

Table 3-3 presents the results of analyses contrasting the Filmloop and Filmstrip media. Of the eight contrasts made, only one significant difference, at the .10 level, was found. In Experiment Two, in which a Booklet presented the verbal component, the Filmloop presentation was found to be superior to the Filmstrip presentation as measured by the performance subtest. For all other contrasts, the findings of NSD were retained, with confidence, since the power of the tests was .99.

The results of Experiments One and Two supported the hypothesis of no significant differences in effectiveness for Filmloop and Filmstrip multimedia presentations used in an independent learning setting.

TABLE 3-1

SUMMARY OF SIGNIFICANT Fs FOR EXPERIMENTS ONE AND TWO--
EFFECTIVENESS MEASURES

Source	Experiment	Subtest			Total Test
		Verb.	Pict.	Perf.	
Media	1				
	2			*	
Modes	1				
	2				
Age × Media	1				
	2				
Age × Modes	1				
	2				
Media × Modes	1	***			**
	2				
Age × Media × Modes	1				
	2	**			

*p < .10.
**p < .05.
***p < .01.

TABLE 3-2

SUMMARY OF SIGNIFICANT Fs FOR EXPERIMENTS THREE AND FOUR--
EFFECTIVENESS MEASURES

Source	Experiment	Subtest			Total Test
		Verb.	Pict.	Perf.	
Media	3		*		*
	4	**	**		***
Modes	3				
	4				
Age × Media	3				
	4				
Age × Modes	3				
	4				
Media × Modes	3	*			
	4				
Age × Media × Modes	3				
	4	***			**

*p < .10.
**p < .05.
***p < .01.

TABLE 3-3

EFFECTIVENESS: MEANS, t TESTS, AND SMALLEST MEANINGFUL DIFFERENCES FOR PICTORIAL PRESENTATION CONTRASTS

Experiments	Treatments	Effectiveness Measures (Mean Correct Responses)							
		Verbal Subtest		Pictorial Subtest		Performance Sub.		Total	
		$\bar{X}$	Statistic	$\bar{X}$	Statistic	$\bar{X}$	Statistic	$\bar{X}$	Statistic
Medium Presenting Verbal Component									
#1 TAPE	Filmloop	4.21	t = .59	3.96	t = .00	2.58	t = .04	10.75	t = .33
	Filmstrip	4.52	SMD = 1.45	3.96	SMD = 1.17	2.57	SMD = 1.04	11.04	SMD = 2.38
#2 BOOKLET	Filmloop	4.57	t = .21	4.48	t = 1.63	3.48	t = 1.68*	12.52	t = 1.41
	Filmstrip	4.46	SMD = 1.39	3.79	SMD = 1.15	2.63	SMD = 1.39	10.92	SMD = 3.12

Note.--Power $(1 - \beta) \geq .99$, when the "smallest meaningful difference (SMD)" is .80 standard deviation and $\alpha = .10$.

*$p < .10$.

Hypothesis 1.2

As measured by the dependent variables for effectiveness, no significant differences in mean scores will be found between audio Tape and Booklet media for the populations sampled.

Table 3-4 presents the results of analyses contrasting the Tape and Booklet media. Of the eight contrasts made, five significant differences at or beyond the .10 level were found.

In Experiment Three, in which Filmloops presented the pictorial component, the Tape presentation was found to be superior to the Booklet presentation as measured by the pictorial subtest and by the total test. In Experiment Four, in which a Filmstrip presented the pictorial component, the Booklet presentation was found to be superior to the Tape presentation as measured by the verbal and pictorial subtests and by the total test. This is contrary to Nielsen's pilot study in which no significant differences in effectiveness were found between these two media.

The results of Experiments Three and Four failed to support the hypothesis of no significant differences in effectiveness for Tape and Booklet multimedia presentations in an independent learning setting.

To the contrary, the results indicating the superiority of Tape with Filmloop and Booklet with Filmstrip presentation suggest an interaction of these four media not directly tested in the study.

Hypothesis 1.3

As measured by the dependent variable for effectiveness, no significant differences in mean scores will be found between Iconic and Symbolic modes for the population sampled.

Table 3-5 presents the results of analyses contrasting the Iconic and Symbolic versions of the multimedia lessons. Of the sixteen contrasts made, only one significant difference at the .10 level was found. In Experiment One the Iconic mode was found to be superior to the Symbolic mode as measured by the pictorial subtest.

In Experiment Two a similar result missed significance at the .10 level by only .01 of a point. For all other contrasts, the findings of NSD were retained with confidence, power being greater than .99.

The results of all four experiments tended to support the hypothesis of no significant difference in effectiveness for Iconic and Symbolic modes of multimedia lessons used in an independent learning setting.

TABLE 3-4

EFFECTIVENESS: MEANS, t TESTS, AND SMALLEST MEANINGFUL DIFFERENCES FOR VERBAL PRESENTATION CONTRASTS

Experiments	Treatments	Effectiveness Measures (Mean Correct Responses)							
		Verbal Subtest		Pictorial Subtest		Performance Sub.		Total	
		$\bar{X}$	Statistic	$\bar{X}$	Statistic	$\bar{X}$	Statistic	$\bar{X}$	Statistic
Medium Presenting Pictorial Component									
#3 FILMLOOP	Tape	5.08	t = .40	4.88	t = 2.02**	3.33	t = 1.07	13.29	t = 1.66*
	Booklet	4.92	SMD = 1.13	4.04	SMD = 1.14**	2.88	SMD = 1.18	11.83	SMD = 2.43*
#4 FILMSTRIP	Tape	3.92	t = 1.76*	3.58	t = 2.02**	2.79	t = 1.34	10.29	t = 2.41***
	Booklet	4.71	SMD = 1.24*	4.54	SMD = 1.31**	3.45	SMD = 1.38	12.71	SMD = 2.77***

Note.--Power $(1 - \beta) \geq .99$, when the "smallest meaningful difference (SMD)" is .80 standard deviation and $\alpha = .10$.

*$p < .10$.
**$p < .05$.
***$p < .01$.

TABLE 3-5

EFFECTIVENESS: MEANS, t TESTS, AND SMALLEST MEANINGFUL DIFFERENCES FOR MODES OF REPRESENTATION CONTRASTS

Experiments	Treatments	Effectiveness Measures (Mean Correct Responses)							
		Verbal Subtest		Pictorial Subtest		Performance Sub.		Total	
		$\bar{X}$	Statistic	$\bar{X}$	Statistic	$\bar{X}$	Statistic	$\bar{X}$	Statistic
Medium Presenting Verbal Component									
#1 TAPE	Iconic	4.65	$t = 1.08$	4.30	$t = 1.64^*$	2.52	$t = .27$	11.48	$t = 1.34$
	Symbolic	4.08	SMD = 1.44	3.63	SMD = 1.13	2.63	SMD = 1.03	10.33	SMD = 2.34
	Iconic	4.65	$t = .55$	4.48	$t = 1.63$	3.08	$t = .16$	12.22	$t = .87$
	Symbolic	4.38	SMD = 1.38	3.79	SMD = 1.15	3.00	SMD = 1.43	11.21	SMD = 3.16
Medium Presenting Pictorial Component									
#3 FILMLOOP	Iconic	5.08	$t = .40$	4.21	$t = 1.18$	3.25	$t = .68$	12.54	$t = .04$
	Symbolic	4.92	SMD = 1.13	4.71	SMD = 1.17	2.96	SMD = 1.18	12.58	SMD = 2.50
#4 FILMSTRIP	Iconic	4.17	$t = .63$	3.96	$t = .42$	3.21	$t = .33$	11.33	$t = .31$
	Symbolic	4.46	SMD = 1.28	4.17	SMD = 1.37	3.04	SMD = 1.40	11.67	SMD = 2.94

Note.--Power $(1 - \beta) \geq .99$, when the "smallest meaningful difference (SMD)" is .80 standard deviation and $\alpha = .10$.

*$p < .10$.

Summary of Findings Relative to General Hypothesis 1.0

The analyses of the effectiveness measures for main effects in all four experiments resulted in the following conclusions:

1. The Filmloop and Filmstrip multimedia presentations were not significantly different in effectiveness.

2. The Tape and Booklet multimedia presentations appeared to be differentially effective; a Tape was more effective with the filmloops while the Booklet was more effective with the filmstrip.

3. The Iconic and Symbolic modes representation of concepts in multimedia lessons appeared to differ little in effectiveness.

4. Since the tests of main effects had high power (.99+), findings of no significant differences were retained with confidence.

Hypotheses of Differential Effectiveness

A specific hypothesis for each of the four possible interactions was derived from General Hypothesis 2.0. Each related to the expectation that significant differential effects would be found when the interactions among Media, Modes, and Ages were analyzed. The results of the factorial ANOVA for tests of conventional nulls of these hypotheses are presented in Appendix D and summarized in Tables 3-1 and 3-2. Figures 3-1 through 3-6 present, graphically, the forms of significant interactions. The power of the statistical tests for all two-way interactions was greater than .48. The power for three-way interactions was known to be very low, but was not calculated.

Hypothesis 2.1

> As measured by the dependent variable for effectiveness, significant interactions of Ages and Media will be found for the populations sampled.

No significant Ages × Media interactions were found at or beyond the .10 level in any of the four experiments. Neither Filmloop and Filmstrip presentations nor Tape and Booklet presentations were differentially effective with 9- and 11-year-old learners. Consequently, the results of the four experiments failed to support the hypothesis, although confidence in retaining the null of no significant interactions was a great deal less (power = .48) than it was for retaining NSD hypotheses for the main effects.

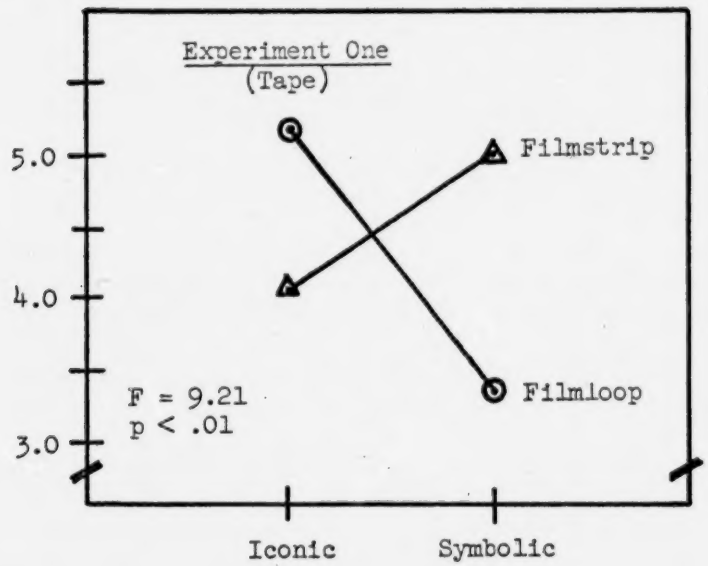


Figure 3-1. Media × Modes Interaction--
Verbal Subtest

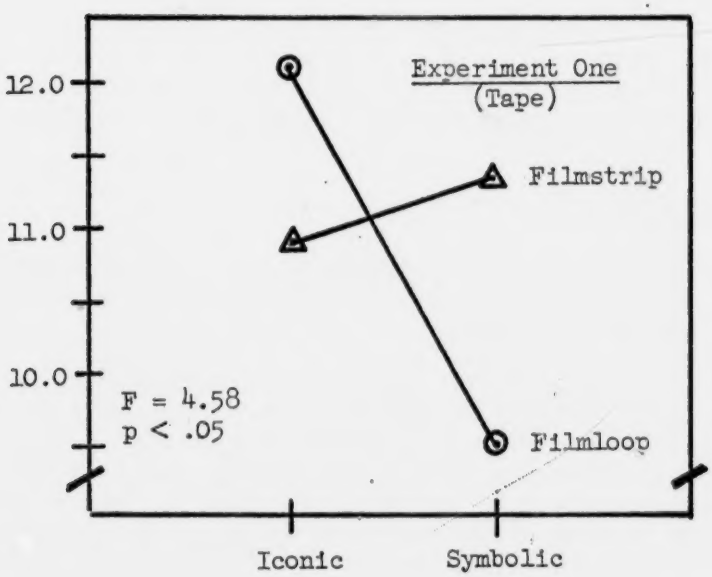


Figure 3.2. Media × Modes Ineraction--
Total Test

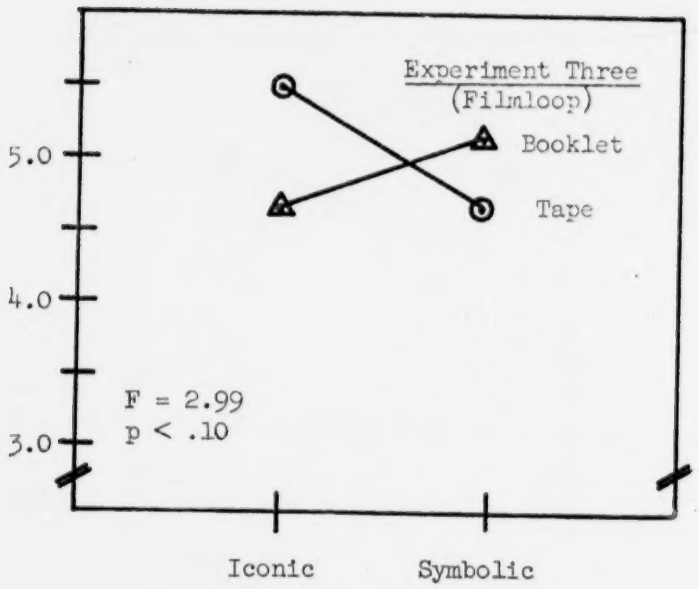
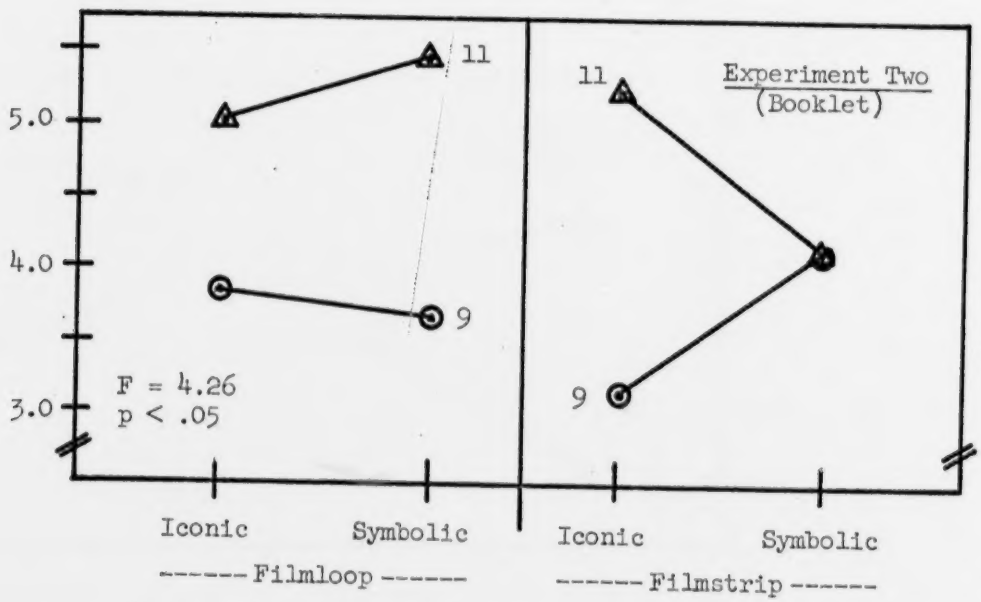


Figure 3-3. Media × Modes Interation--
Verbal Subtest



Figures 3-4. Ages × Media × Modes Interaction--Verbal Subtest

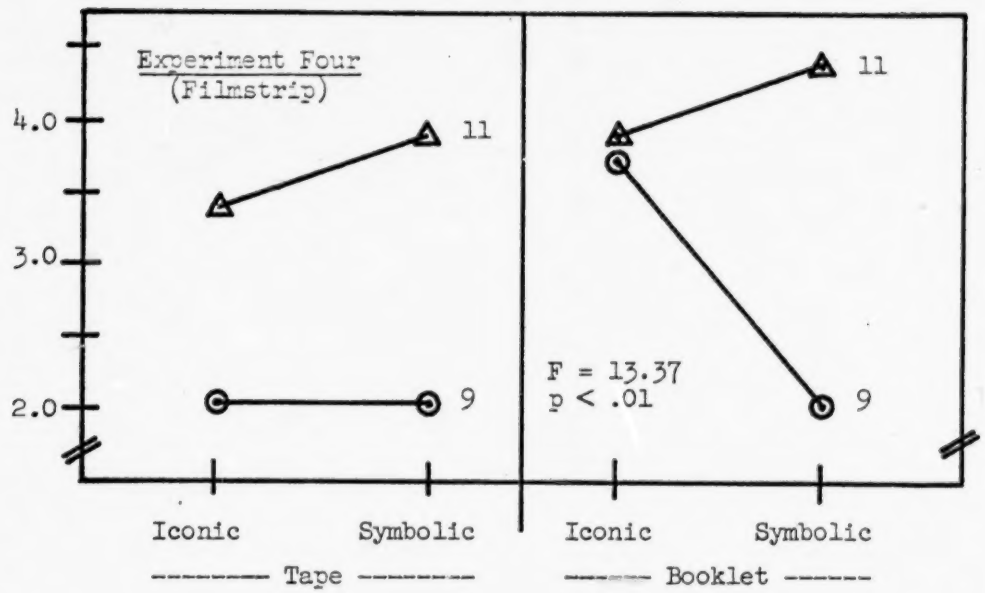


Figure 3-5. Ages × Media × Modes Interaction--Verbal Subtest

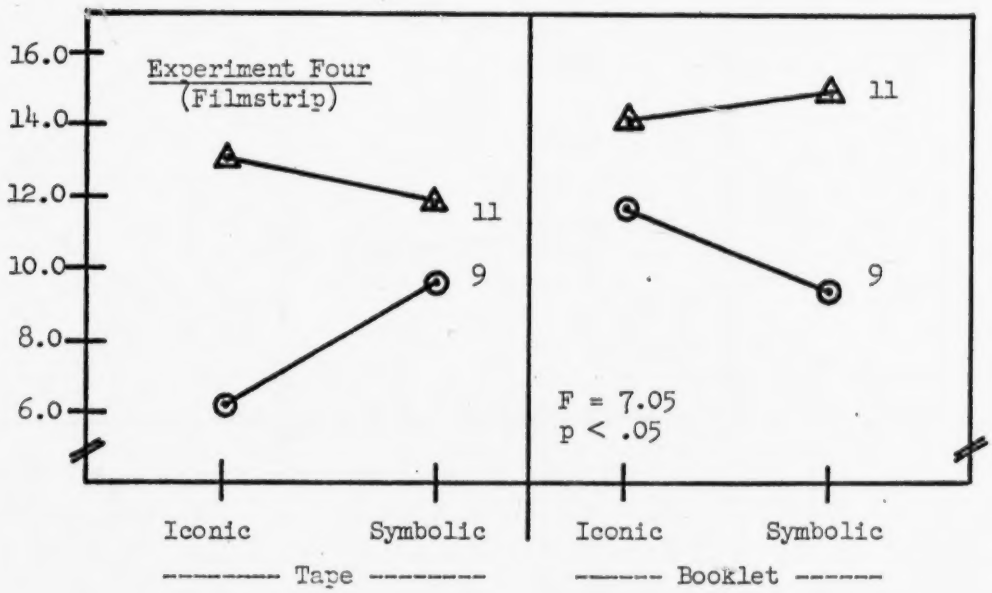


Figure 3-6. Ages × Media × Modes Interaction--Total Test

Hypothesis 2.2

As measured by the dependent variables for effectiveness, significant Ages × Modes interactions will be found for the population sampled.

This hypothesis, although not a sufficient test of the thesis of a congruence of modes of representation and modes or levels of cognitive functioning, provided the most direct test of Nielsen's thesis.

No significant Ages × Modes interactions were found at or beyond the .10 level in any of the four experiments, although the probability of finding any interaction, if one really existed, was only .48. This was contrary to Nielsen's finding of the superiority of the Iconic mode for 9-year-olds but equal effectiveness of Iconic and Symbolic modes for 11-year-olds. Consequently, the results of the four experiments failed to support the hypothesis, offering no evidence of a distinct congruence of modes of representation and level of cognitive functioning as defined in this study.

Hypothesis 2.3

As measured by the dependent variables for effectiveness, significant Media × Modes interactions will be found for the populations sampled.

Figures 3-1, 3-2, and 3-3 present the results of the three Media × Modes interactions significant at or beyond the .10 level. In Experiment One, in which the verbal component was presented by tape, the Iconic mode was more effective than the Symbolic mode with the Filmloop presentation, while the Symbolic mode was more effective than the Iconic mode with the Filmstrip presentation. The form of the interactions as shown in Figures 3-1 and 3-2 were the same for both the verbal subtest and the total test. Since the differences among the means were essentially the same, it appeared that the interaction of the total test was a direct function of the interaction on the verbal subtest.

In Experiment Three, in which the pictorial component was presented by filmloops, the interaction of modes and verbal media was less clearcut, as shown in Figure 3-3. Booklet/Iconic and Tape/Symbolic combinations were equally and relatively ineffective. However, as in Experiment One, the Iconic mode appeared to be more effective than the Symbolic mode with the Filmloop/Tape presentation, although the difference was not as great.

The results of the four experiments failed to provide adequate support for the hypothesis of significant interactions of Media and Modes in multimedia presentations used in an independent learning setting. However, the results do suggest there may be more complex, three-way interactions of Modes and both verbal and pictorial presentation

Media, especially when measured by verbal type tests.

Hypothesis 2.4

> As measured by the dependent variables for effectiveness, significant Ages × Media × Modes interactions will be found for the populations sampled.

Figures 3-4, 3-5, and 3-6 present the results of the three Ages × Media × Modes interactions significant at or beyond the .10 level. In Experiments Two and Four the three variables interacted as measured by the verbal subtest (Figures 3-4 and 3-5). In Experiment Four, which was similar to Nielsen's pilot study, the interaction of Modes with Ages was similar to and even more distinctive than the interaction of Ages and Modes in the pilot study, but only for the Booklet presentation and not for both Tape and Booklet presentations as in the pilot study. Thus partial support for the congruence thesis was found in this three-way interaction, while it appeared in the two-way interaction in the pilot study. However, findings contrary to the thesis were also found. The interaction of Ages and Modes for the Filmstrip presentation in Experiment Two are shown in the right half of Figure 3-4 and are clearly opposite the expected form shown in the right half of Figure 3-5. A similar though less distinctive interaction appeared for the Ages × Media interaction for the Tape presentation shown on the left half of Figure 3-6.

The results of the four experiments failed to provide adequate support for the hypothesis of significant interaction of Ages, Media, and Modes in multimedia presentations used in an independent learning setting. However, power was quite low for these three-way analyses, i.e., the probability of finding such interactions if they really existed was very low. Since a number of distinctive, if opposite, interactions were found, the results are inconclusive; there is no basis for any conclusion, with confidence, without further more powerful tests of the hypothesis.

Summary of Findings Relative to General Hypothesis 2.0

The analyses of the effectiveness measures for interactions in all four experiments resulted in the following conclusions:

1. The Filmloop and Filmstrip multimedia presentations were not differentially effective for 9- and 11-year-olds.

2. The Tape and Booklet multimedia presentations were not differentially effective for 9- and 11-year-olds.

3. The Iconic and Symbolic modes of representation were not differentially effective for 9- and 11-year-olds.

4. Based upon the findings, above, there was no evidence of a clearcut congruence of modes of representation and levels of cognitive functions as presented in this study.

5. There was some evidence to suggest the Iconic mode was more effective with Filmloop presentation while the Symbolic mode was more effective with Filmstrip presentations.

6. Since the above findings were not supported in all experiments, there may be a complex three-way interaction of Modes and both Media, verbal and pictorial.

7. There was some evidence to suggest that Iconic and Symbolic modes interact in complex, though not consistent ways with Media and Ages.

8. Since power for the tests of significant interactions was low (.48) for two-way interactions and very low for three-way interactions, none of the nulls of the hypotheses were retained with much confidence, requiring further investigation and testing.

Hypotheses of Significant Differences in Efficiency

Two specific hypotheses were devised from General Hypothesis 3.0. Both related to the expectation that significant differences in efficiency, i.e., time-to-completion, would be found when the main effects of the media were analyzed. The results of the factorial ANOVA for these hypotheses are presented in Appendix D and are summarized in Tables 3-6 and 3-7. Tables 3-8 and 3-9 present the results of pre-planned contrasts.

Values for the t tests and results of one-tailed tests of significance appear for lesson time, written test time, and total time (including performance test time). The power of the statistical tests was greater than .99.

Hypothesis 3.1

> As measured by the dependent variables for efficiency, the mean times for Filmloop presentations will be significantly greater than the mean times for Filmstrip presentations for the populations sampled.

Table 3-8 presents the results of analyses contrasting mean times for the Filmloop and Filmstrip media.

All three time measures differed significantly at or beyond the .05 level in experiment One, in which the verbal component was presented by tape, while none were significant in Experiment Two in which the verbal component was presented by booklet.

TABLE 3-6

SUMMARY OF SIGNIFICANT Fs FOR EXPERIMENTS ONE AND TWO--
EFFICIENCY MEASURES

Source	Experiment	Lesson Time	Test Time	Total Time
Media	1	***	**	**
	2			
Modes	1			
	2	*		**
Age × Media	1		**	*
	2	**		**
Age × Modes	1			
	2			
Media × Modes	1			
	2	***	**	***
Age × Media × Modes	1		***	
	2			

*p < .10.
**p < .05.
***p < .01.

TABLE 3-7

SUMMARY OF SIGNIFICANT Fs FOR EXPERIMENTS THREE AND FOUR--
EFFICIENCY MEASURES

Source	Experiment	Lesson Time	Test Time	Total Time
Media	3	***		***
	4		***	**
Modes	3			
	4			
Age × Media	3			
	4			
Age × Modes	3			
	4			
Media × Modes	3	**		*
	4			
Age × Media × Modes	3	**		***
	4			

*p < .10.
**p < .05.
***p < .01.

TABLE 3-8

EFFICIENCY: MEANS AND t TESTS FOR PICTORIAL PRESENTATION CONTRASTS

		Efficiency Measures (Mean Time in Minutes)					
		Lesson		Written Test		Total	
	Treatments	$\bar{X}$	Statistic	$\bar{X}$	Statistic	$\bar{X}$	Statistic
Medium Presenting Verbal Component							
#1 TAPE	Filmloop	35.04	t = 5.66	11.79	t = 2.32	49.50	t = 2.18
	Filmstrip	26.83	***	15.00	**	44.34	**
#2 BOOKLET	Filmloop	30.09	t = .12	11.74	t = 1.44	44.00	t = .56
	Filmstrip	29.79		13.67		45.88	

**$p < .05$.
***$p < .01$.

TABLE 3-9

EFFICIENCY: MEANS AND t TESTS FOR VERBAL PRESENTATION CONTRASTS

		Treatments	Efficiency Measures (Mean Time in Minutes)					
			Lesson		Written Test		Total	
			$\bar{X}$	Statistic	$\bar{X}$	Statistic	$\bar{X}$	Statistic
Medium Presenting Pictorial Component								
	#3 FILMLOOP	Tape	35.04	t = 3.28	14.38	t = 1.22	51.92	t = 2.70
		Booklet	30.58	***	12.75		46.33	***
	#4 FILMSTRIP	Tape	23.62	t = .08	13.92	t = 2.74	41.21	t = 1.84
		Booklet	23.45		11.25	***	37.00	** .99

**p < .05.
***p < .01.

The results of Experiment One supported the hypothesis that filmstrip multimedia lessons are more efficient than filmloop multimedia lessons used in an independent learning setting. However, Experiment Two failed to support it. As noted earlier, there appeared to be significant interactions among the four media which accounted for differing results from experiment to experiment.

Hypothesis 3.2

> As measured by the dependent variables for efficiency, the mean times for Tape presentations will be significantly greater than the mean times for Booklet presentation for the populations sampled.

Table 3-9 presents the results of analyses contrasting mean times for the Filmloop and Filmstrip media. All but two of the measures differed significantly at or beyond the .05 level in Experiments Three and Four.

Surprisingly, lesson times in Experiment Four did not differ significantly, a finding contrary to expectation and to the finding of the pilot study.

The results of Experiments Three and Four in general supported the hypothesis that booklet multimedia lessons are more efficient than tape multimedia lessons used in an independent learning setting.

Summary of Findings Relative to Hypothesis 3.0

The analyses of the efficiency measures for main effects of the media in all four experiments resulted in the following conclusions:

1. Filmstrip presentations were more efficient than Filmloop presentations, but only when the verbal component was presented by Tape.

2. Booklet presentations appeared to be more efficient than Tape presentations as the medium by which the verbal component is presented.

3. Since results differed in Experiment One and Experiment Two, there appeared to be an interaction among the four media not directly investigated in this study.

Hypotheses of Differential Efficiency

Three hypotheses were derived from General Hypothesis 4.0. Each related to the expectation that significant interactions would be found for each of the three dependent variables, lesson time, written test time, and total time.

The results of the factorial ANOVA are presented in Appendix D, and summarized in Tables 3-6 and 3-7. Figures 3-7 through 3-19 present the results of significant interactions at or beyond the .10 level.

Hypothesis 4.1

> As measured by the time to complete a multimedia lesson, significant interactions among Ages, Media and Modes will be found for the populations sampled.

Figures 3-7 through 3-10 present the results of significant interactions for lesson time.

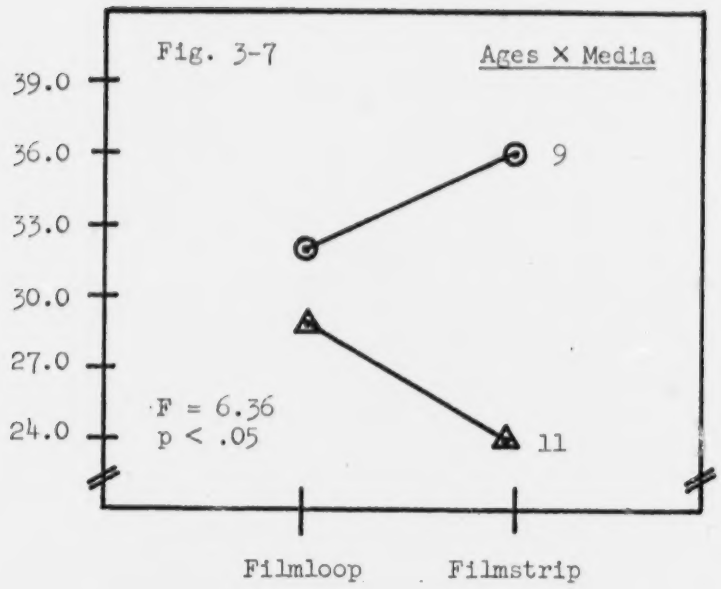
Significant interactions were found only in Experiments Two and Three. In Experiment Two, in which a booklet presented the verbal components, the Filmstrip presentations appeared to be most efficient for 11-year-olds while least efficient for 9-year-olds. Also in Experiment Two, the Iconic mode appeared to be more efficient than the Symbolic mode for the Filmstrip presentations. In Experiment Three, in which filmloops presented the pictorial component, the Symbolic mode appeared to be more efficient than the Iconic mode with Booklet presentations, especially for 11-year-olds.

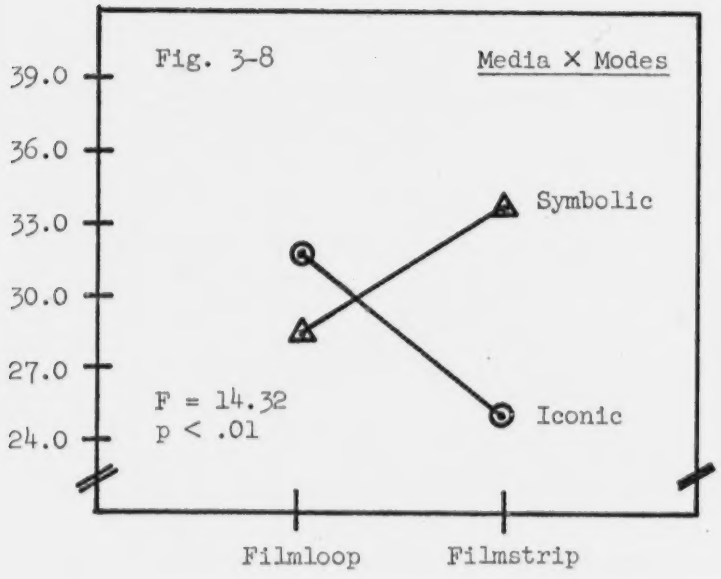
Hypothesis 4.2

> As measured by the time to complete the written test, significant interaction among Ages, Media, and Modes will be found for the populations sampled.

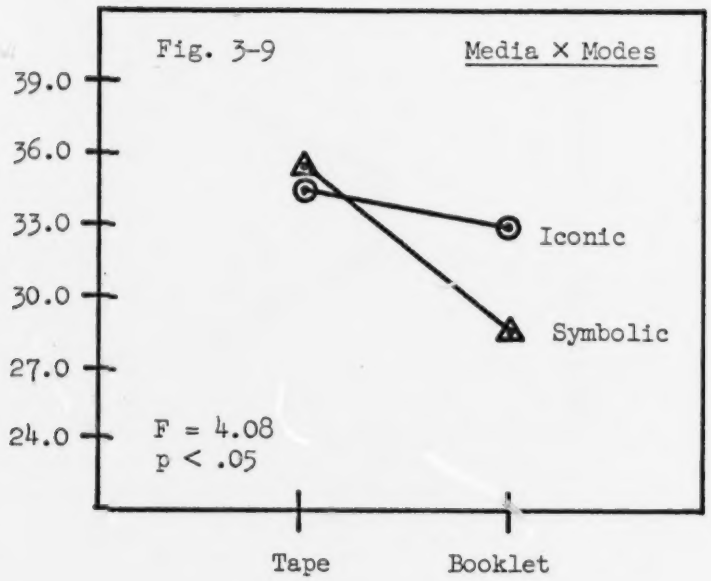
Figures 3-11 through 3-13 present the results of significant interactions for written test time. Only in Experiments One and Two were significant interactions found. In Experiment One, in which a tape presented the verbal component, analysis of the Ages × Media interaction (Figure 3-11) revealed that the Filmloop presentations affected approximately a 13 percent greater mean test time for 9-year-olds than for 11-year-olds while Filmstrip presentations affected approximately a 65 percent greater mean test time for 9-year-olds than for 11-year-olds. Analysis of the three-way interaction in Experiment One (Figure 3-12) revealed that the Iconic mode effected approximately a 47 percent greater mean test time than the Symbolic mode, but only for 9-year-olds and only with Filmstrip presentations.

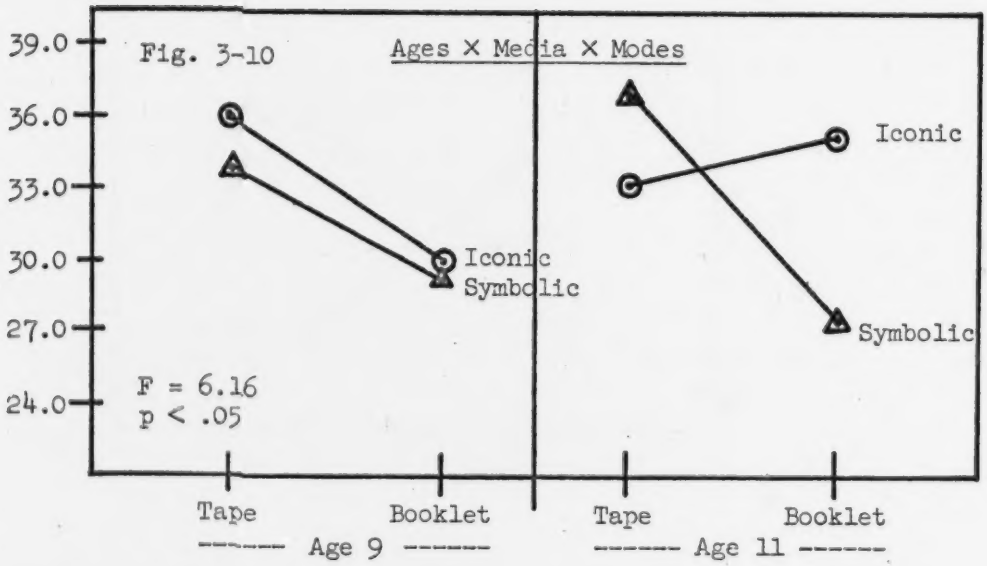
In Experiment Two, in which the booklet presented the verbal component, the Symbolic mode appeared to affect approximately a 33 percent greater mean test time than the Iconic mode, but only with the Filmstrip presentations (Figure 3-13).



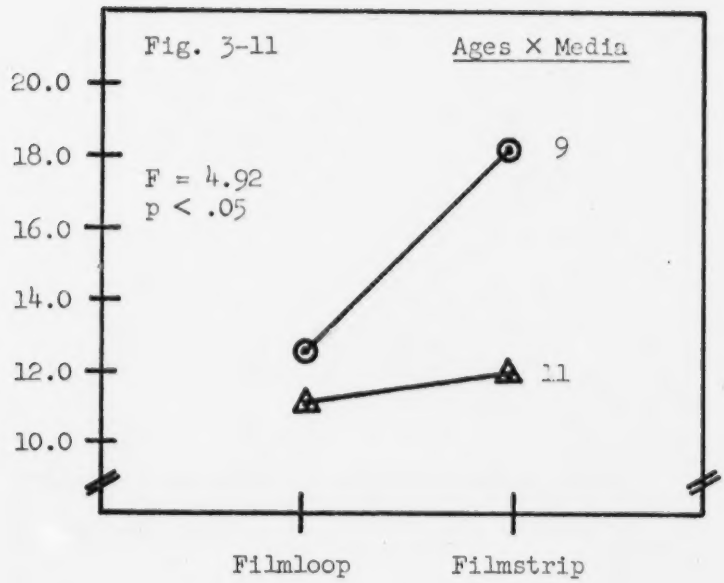


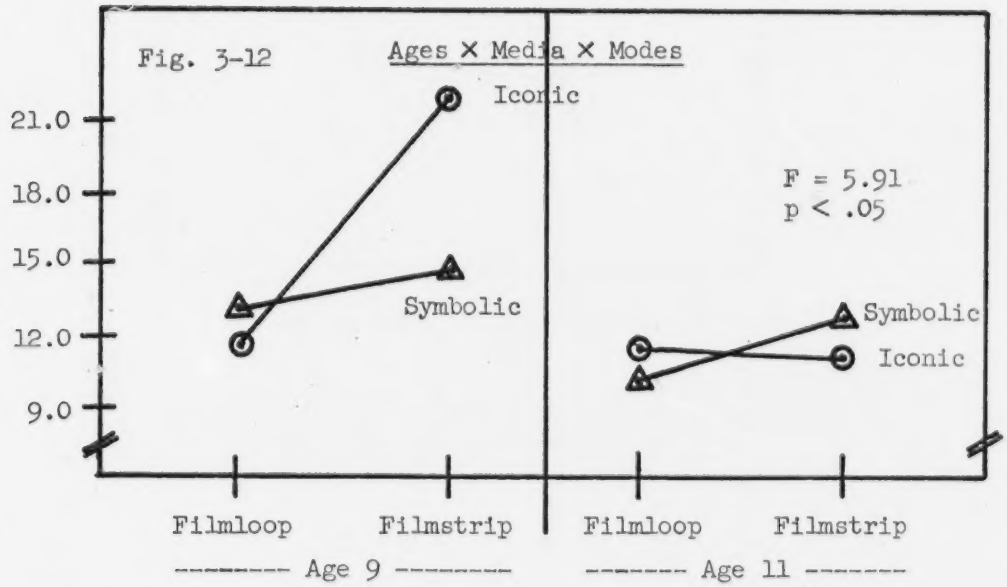
Figures 3-7 and 3-8. Lesson Time Interactions, Experiment Two (Booklet)





Figures 3-9 and 3-10. Lesson Time Interactions, Experiment Three (Filmloop)





• Figures 3-11 and 3-12. Written Test Time Interactions, Experiment One (Tape)

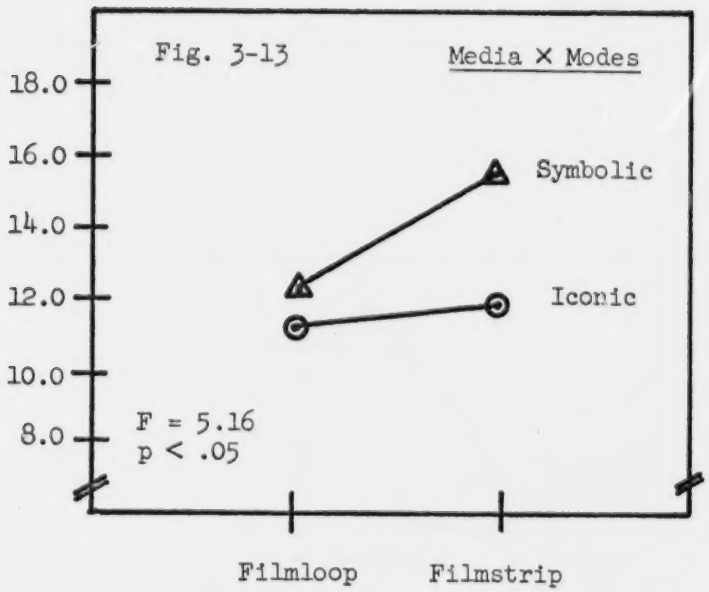


Figure 3-13. Written Test Time Interaction, Experiment Two (Booklet)

Hypothesis 4-3

> As measured by the total time to complete the multimedia lesson and all testing, significant interactions among Ages, Media and Modes will be found for the populations sampled.

Figures 3-14 through 3-19 present the results of significant interactions for total time.

Significant Ages × Media interactions were found in Experiments One and Two while Media × Mode and Ages × Media × Mode interactions were found in Experiments One and Three.

In Experiments One and Two, Filmloop presentations appeared to affect slightly greater means times for 9-year-olds than for 11-year-olds, whereas Filmstrip presentations affected much greater differences (Figures 3-14 and 3-15).

In Experiment One, in which tape presented the verbal component, the Iconic mode clearly appeared to be more efficient than the Symbolic mode (Figure 3-16). However, the analysis of the three-way interaction revealed that the Iconic mode appeared to be much less efficient than the Symbolic mode, but only for 9-year-olds and only with Filmstrip presentations (Figure 3-18).

In Experiment Three, in which filmloops presented the pictorial component, the Iconic mode appeared to be more efficient with Booklet presentations while the Symbolic mode appeared more efficient with Tape presentations (Figure 3-17). However, the three-way interaction revealed that the Symbolic mode appeared to be more efficient than the Iconic mode with Booklet presentations for 11-year-olds, but that the Iconic mode appeared to be more efficient with Tape presentations for 11-year-olds.

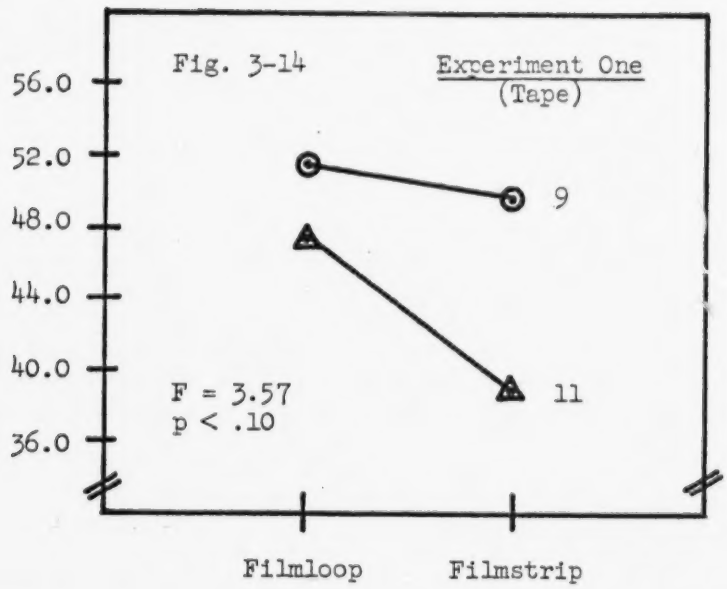
The results of Experiments One through Four failed to provide any consistent or conclusive evidence in support of the last three hypotheses. However, the scatter findings of significant interactions, some differing from experiment to experiment, again suggest the possibility of three-way interactions of Modes and the verbal and pictorial Media.

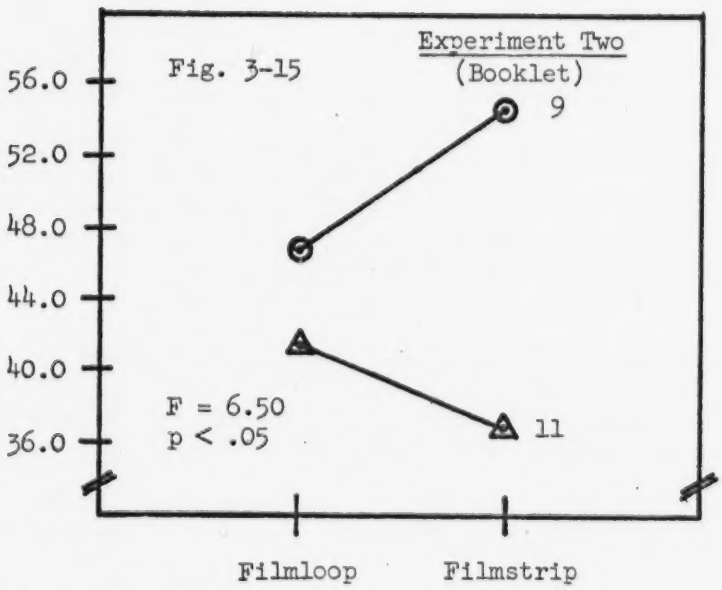
Summary of Findings Relative to Hypothesis 4.0

The analyses of the efficiency measures for interactions in all four experiments resulted in the following conclusions:

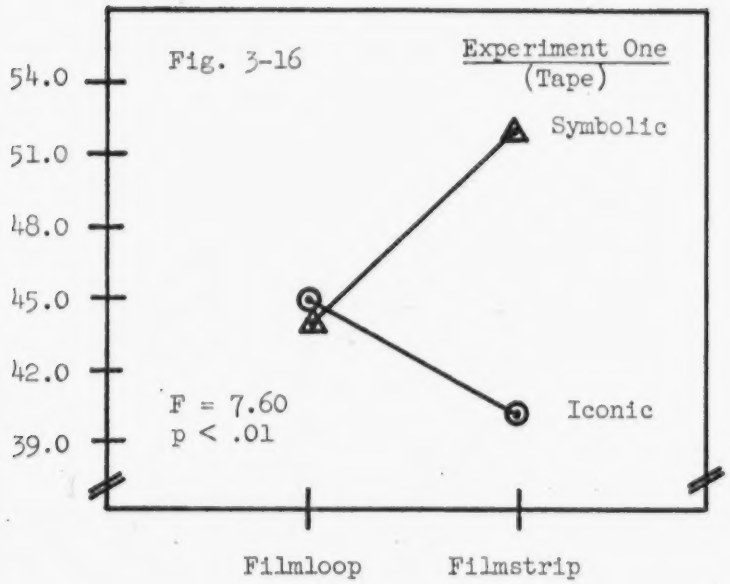
1. There was some evidence to suggest that the Filmstrip multimedia presentations were more time efficient for 11-year-olds than for 9-year-olds.

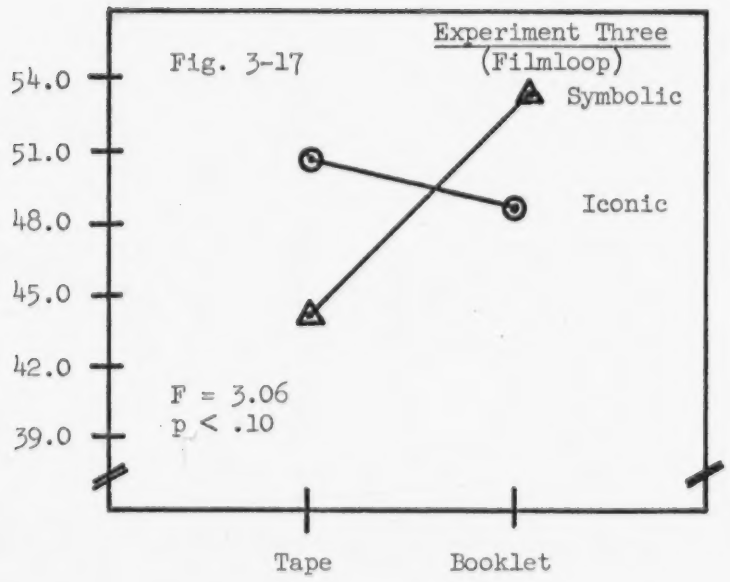
2. There was some evidence to suggest that, in general, the Booklet/Iconic multimedia lessons were more time efficient than were Booklet/Symbolic multimedia lessons.



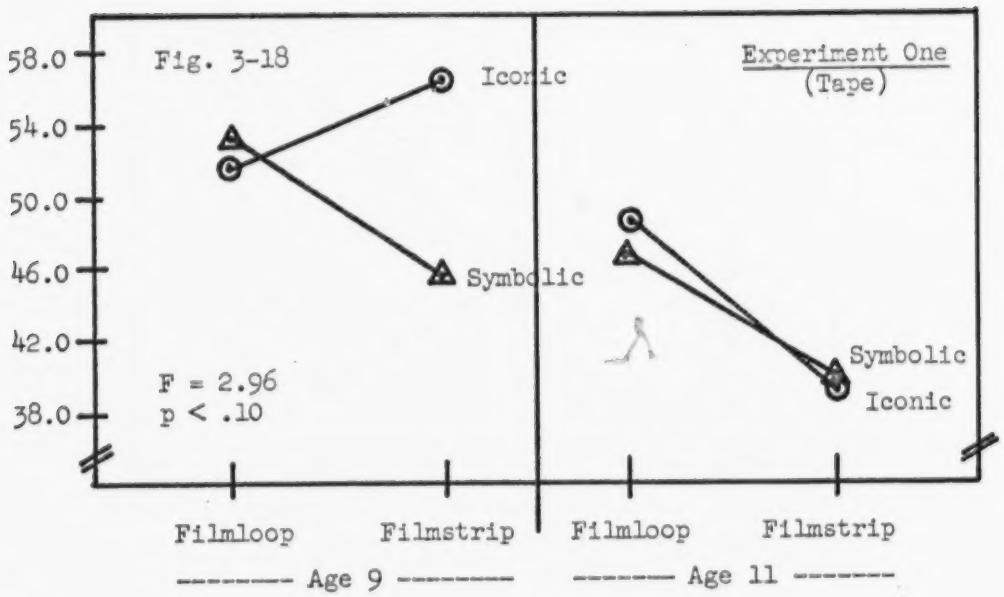


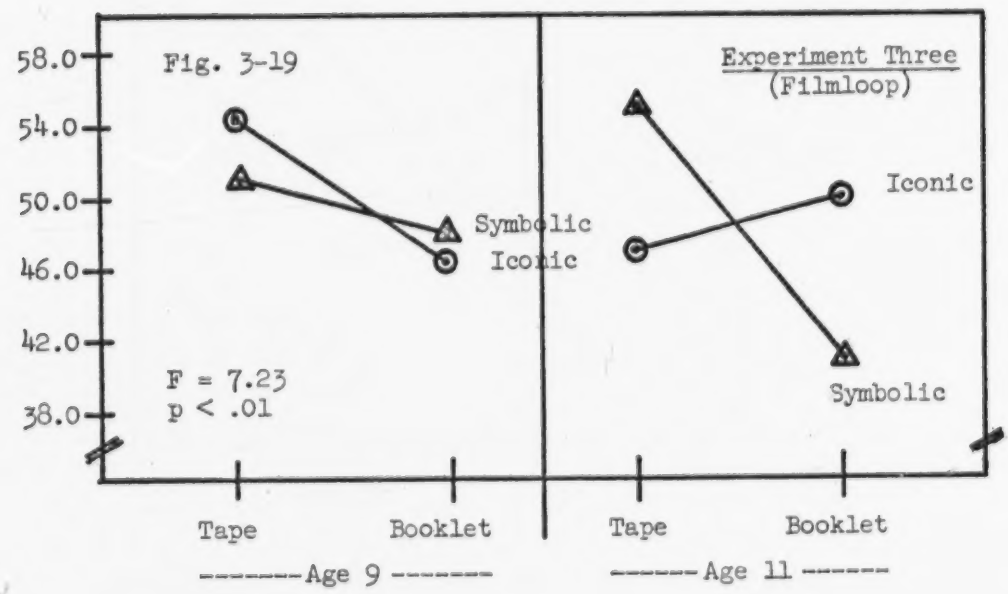
Figures 3-14 and 3-15. Ages × Media Interactions, Total Time





Figures 3-16 and 3-17. Media × Modes Interaction, Total Time





Figures 3-18 and 3-19. Ages × Media × Modes Interactions, Total Time

3. Since the above findings were not supported in all experiments, there may be a complex interaction of Modes and Media, pictorial and verbal.

Significant Age Differences

Although 11-year-olds were expected to do significantly better than 9-year-olds, that expectation was not one of the major hypotheses to be tested in this study. Consequently the earlier ANOVA summaries omitted the Ages variable. Table 3-10 presents a summary of ANOVA results for the Ages variable for all experiments and all dependent variables.

TABLE 3-10

SUMMARY OF SIGNIFICANT Fs FOR THE AGES VARIABLE FOR ALL EXPERIMENTS

Experiment	Scores			Times			
	Verbal	Pictorial	Performance	Total	Lesson	Test	Total
One	***			**	***		***
Two	***	*	*	***	***	***	***
Three	**		**	***		*	
Four	***	***	***	***		***	

*p < .10.
**p < .05.
***p < .01.

CHAPTER IV

CONCLUSIONS, DISCUSSION AND MAJOR FINDINGS

This chapter presents conclusions and discussion of the major findings of this study. The results of the analyses of the four experiments are summarized in Tables 4-1 and 4-2.

The Congruence of Modes

The thesis postulated by Nielsen (1970) of a probable congruence of modes of representation in instruction and modes or levels of knowing or cognitive functioning provided the major focus for this study.

The first major finding of this study was that there was no apparent congruence of the modes of representing concepts in multimedia lessons and the age levels assumed to represent differing levels of cognitive functioning. This was evidenced, directly, by the lack of a single significant Ages × Modes interaction in any of the four experiments. It was concluded that, at the least, such a congruence was not to be found in either the style and design of the multimedia lessons or in the age levels chosen for this study. This finding may be a result, primarily, or two assumptions, both basic to this study: (1) that distinctly Iconic and Symbolic modes can be developed in multimedia lessons for independent learning; and (2) that ages can generally represent a single or most pervasive level of cognitive functioning. Since a level of cognitive functioning is a stage or period of intellectual development, overlapped and overlapping other levels, an elementary pupil may at a given time be functioning at several levels, depending upon his development, knowledge, and experience.

Modes Variable

The first experimental objective of the study was to determine the immediate effects, in terms of effectiveness and efficiency, of Iconic and Symbolic modes of representing concepts in the verbal component of a multimedia lesson.

As expected, in general there were no significant differences in effectiveness between the two modes. And in only one experiment was a mode, the Iconic, more time efficient than the other. This was the second major finding of the study.

Verbal Media Variable

The second experimental objective of the study was to determine

TABLE 4-1

SUMMARY OF RESULTS FOR EFFECTIVENESS MEASURES

	Tests			
	Verbal	Pictorial	Performance	Total
#1 Tape Experiment	[FL/I > FL/S]*** [FS/S > FS/I]		FL > FS*	FL/I > FL/S
#2 Booklet Experiment	[FS/I/11 > FS/I/9]** [FS/S/11 = FS/S/9]			
#3 Filmloop Experiment	[B/S > T/S]* [T/I > B/I]	T > B*		T > B*
#4 Filmstrip Experiment	B > T** [B/S/11 > B/S/9]*** [B/I/11 = B/I/9]	B > T**		B > T*** [T/I/11 > T/I/9]** [B/S/11 > B/S/9]

*p < .10.
**p < .05.
***p < .01.

TABLE 4-2

SUMMARY OF RESULTS FOR EFFICIENCY

	Times		
	Lesson	Written Test	Total
#1 Tape Experiment	FS > FL***	FS > FL** [FS/11 > FS/9]** [FS/S/9 > FS/I/9]***	FS > FL** [FS/11 > FS/9]* [FS/I > FS/S]*
#2 Booklet Experiment	[FS/11 > FS/9]** [FS/I > FS/S]***	[FS/I > FS/S]**	[FS/11 > FS/9]**
#3 Filmloop Experiment	B > T*** [B/I > B/S]** [B/S/11 > B/I/11]**		B > T*** [T/S > T/I]* [B/I > B/S] [B/S/11 > T/S/11]*** [B/I/9 > T/I/9]
#4 Filmstrip Experiment		B > T***	B > T**

*p < .10.
**p < .05.
***p < .01.

the immediate effects, in terms of effectiveness and efficiency, of Tape and Booklet media presenting the verbal component of a multimedia lesson.

Contrary to expectation, significant differences in effectiveness were found. When results were compared across experiments, it appeared that the media were differentially effective, i.e., their effectiveness was relative to the medium presenting the pictorial component. Tape was more effective in the filmloop experiment while the Booklet was more effective in the filmstrip experiment. This was the third major finding of the study.

The fourth major finding, as expected, was that the Booklet proved to be more time efficient than the Tape as a means of presenting the verbal component of instruction.

Pictorial Media Variable

The third experimental objective of the study was to determine the immediate effects, in terms of effectiveness and efficiency, of Filmloop and Filmstrip media presenting the pictorial component of a multimedia lesson.

The fifth major finding was as expected; Filmloop and Filmstrip presentations did not differ, significantly, in their effectiveness, despite the inherent motion properties of the subject matter, flipcard animation.

In terms of efficiency, it appeared that the superiority of the filmstrip medium was relative to the medium presenting the verbal component in the multimedia lesson. In the tape experiment the filmstrip was significantly more time efficient while in the booklet experiment there were no differences. This is related to the sixth finding of the study.

Interactions of Variables

The fourth experimental objective of the study was to determine the immediate interaction effects, in terms of effectiveness and efficiency, of representation modes, presentation media, and ages.

No clearcut or consistent pattern of interactions was found in this study. However, analyses of the interactions in all four experiments suggested a sixth possible finding. It was concluded that the results indicated a possible complex, three-way interactions among verbal and pictorial Media and Modes, interactions not directly investigated in this study.

Measures

The fifth experimental objective of this study was to determine

the effectiveness of the experimental treatments when measured by verbal- and pictorial-type items, performance (transfer) tasks, a combination of such measures, and time.

A seventh finding of the study was that, in general, the subtest composed of verbal-type items was more sensitive to interactions among variables than were the pictorial or performance tests. This suggests that the supposed effectiveness may be more a function of the type or mode of measurement than a function of the treatment mode or media.

Paradigm

The final experimental objective of the study was to assess the import of the experimental paradigm for media theory, research and design.

The review of the literature and research in Chapter II was an attempt to relate Nielsen's thesis and the paradigm to media theory and research. The chapter, thus, was considered a basic component of the assessment.

A second component of such an assessment consisted of the findings of this exploratory study. The findings seem to suggest to the investigators that even if there is a congruence of modes of representation in instructional events and modes of cognitive functioning, such a relationship is not palpable, i.e., it is not technologically practical, at least in the design of multimedia lessons for 9- and 11-year-olds in independent learning settings.

However, the findings do seem to suggest that the modes or styles of the verbal component developed in this study are differentially effective, interacting more with Media presentation variables than with Ages. Therefore, the use of a modified paradigm, one which permits the analysis of complex interactions among such verbal modes or styles and several media presentations variables, is recommended. From studies using such a paradigm should come more conclusive evidence of the differential effectiveness and efficiency of various multimedia lesson designs used by young learners in independent learning settings.

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APPENDIX A

ICONIC AND SYMBOLIC TEXTS OF THE MULTIMEDIA LESSONS

(Audio Scripts)

TAPE AND FILMLOOP

This tape has been prepared to help you learn about the film sequence you will see with the projector. In a few seconds you will hear a number. After you hear this number listen to the tape until you hear LOOK AGAIN, then stop the tape and turn the projector on until it stops by itself.

NUMBER 1.

This course is about to begin in a few seconds. In order to learn the film sequence you must listen to this tape attentively. After explanation you will hear STOP THE TAPE AND LOOK AGAIN, it means: STOP the tape and START the projector and study the film until it stops by itself. Let's try it. Don't forget after the tape said LOOK AGAIN, STOP the tape and START the projector.

(Graphic Display)

START

1

NUMBER 2.

This course will have a lesson on animation

LOOK AGAIN.

(Graphic Display)

FILMSTRIP

2

NUMBER 3.

If you do not know how to focus the projector ask the teacher for help.

LOOK AGAIN.

(Graphic Display)

Focus on Next Frame

3

NUMBER 4.

Before beginning the course on animation be sure you know how to proceed. If you do not know ask the teacher to explain what you do not understand.

LOOK AGAIN.

(Graphic Display)

WHAT IS ANIMATION?

4

When you hear a NUMBER on the tape it means:

1st LISTEN to the tape until you hear STOP THE TAPE AND LOOK AGAIN.

2nd STOP the tape.

3rd START the projector and LOOK at the short film sequence.

4th START the tape again and LISTEN to it until you hear LOOK AGAIN.

TAPE AND FILMSTRIP

This tape has been prepared to help you learn about the picture you will see with the projector. In a few seconds you will hear the tape say a number. After you have heard this number, STOP the tape, turn the filmstrip to the picture of the number, and START the tape, turn the filmstrip to the picture of the number, and START the tape again. Let's try.

NUMBER 1.

This course is about to begin in a few seconds. In order to learn about the picture you must listen to this tape attentively. After each explanation given by the tape you will hear the tape say STOP THE TAPE AND LOOK AGAIN, it means STOP the tape because the explanation is over, and study the picture attentively. Let's try it.
Don't forget after you have heard
"LOOK AGAIN" STOP the tape and study the picture.

LOOK AGAIN.

NUMBER 2.

Picture number 2 is supposed to be on the screen now. This course will have a lesson on ANIMATION.

LOOK AGAIN.

NUMBER 3.

If you do not know how to focus the projector, ask the teacher for help.

LOOK AGAIN.

NUMBER 4.

Before beginning the course on animation be sure you know how to proceed. If you do not know ask the teacher to explain what you do not know.

LOOK AGAIN.

When you hear a NUMBER that means:

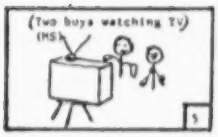
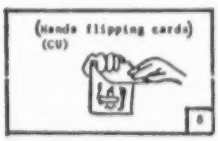
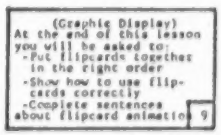
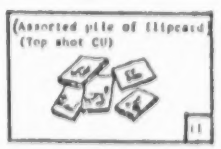
1st STOP the tape and TURN the filmstrip to the picture of the NUMBER you have just heared.

2nd START the tape and listen to it until you hear LOOK AGAIN.

3rd STOP the tape and STUDY the picture.

4th START the tape and LISTEN until the next NUMBER.

78/79

ICONIC TAPE STRIP		SYMBOLIC TAPE SCRIPT
NUMBER 5. Most school children see many moving picture cartoons. They see some of them of TV LOOK AGAIN		NUMBER 5. Most children see many moving picture cartoons. They see some of them on TV. LOOK AGAIN.
NUMBER 6. Some children learn how to make their own moving picture cartoons. They learn about animation. Some even learn how to make movie films of their animated drawings. LOOK AGAIN		NUMBER 6. Some children learn how to make their own moving picture cartoons. They learn about animation. Some even learn how to make movie films of their animated drawings. LOOK AGAIN.
NUMBER 7. Most boys and girls learn a simple way of animating drawing pictures, first. They use sets of cards with drawings on them. LOOK AGAIN		NUMBER 7. Most boys and girls learn a simple way of animating drawn pictures. They use sets of cards with drawings on them. LOOK AGAIN.
NUMBER 8. When the cards are put together in the right order and flipped, the picture seems to move. LOOK AGAIN		NUMBER 8. When the cards are put together in the right order and flipped, the picture seems to move. LOOK AGAIN.
NUMBER 9. After you have done this lesson, you will put some flipcards together, and show someone how to use them. Then you will take a test. It will be about flipcards and animation. LOOK AGAIN		NUMBER 9. After you have done this lesson you will put some flipcards together. You will show someone how to use them. Then you will take a test. It will be about flipcards and animation. LOOK AGAIN.
NUMBER 10. This lesson is about flipcards. LOOK AGAIN.		NUMBER 10. This lesson is about flipcards. LOOK AGAIN.
NUMBER 11. See what the picture shows you. What you see in the pictures should help you to answer the questions. Pictures can be animated with set of flip-cards. See what is drawn on the flipcards. LOOK AGAIN.		NUMBER 11. Pictures can be animated with sets of flipcards. On each flipcard is a drawing. LOOK AGAIN.

NUMBER 12.

Do you think that each set of flipcards has the same number of cards?

LOOK AGAIN

NUMBER 13.

Now you will learn about one of two ways of animating drawn pictures.
Do you think you know what will seem to move when this set is flipped?
Will it be the ship? Will it be the castle?

LOOK AGAIN.

NUMBER 14.

See what things in the animated picture are in the same place in every flipcard drawing.
Do you see what things in the picture are in different places in each flipcard drawing?
Is the ship closer to the castle in the first flipcard than in the last flipcard?
Are the castle, hill, and waves in the same places in the drawings on the first and last flipcards?

LOOK AGAIN.

NUMBER 15.

See the flipcard where the animated ship starts.
On which flipcard does the animated ship end up?
Is the ship in very different places in drawings that are far apart in the flipcard set?

LOOK AGAIN.

NUMBER 16.

What will seem to move when this set is flipped?
Will it be the ball or the tank?

LOOK AGAIN.

NUMBER 17.

Notice the thing that changes its location from flipcard to flipcard.
Do you see what things are in the same places in every flipcard drawing?
Do you see the two flipcards where the ball is in just a little different place in the drawings?
Is the ball in the middle drawing much different from the first and last flipcard drawing?

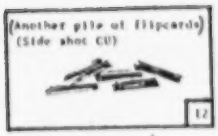
LOOK AGAIN.

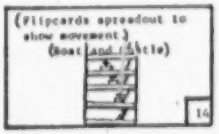
NUMBER 18.

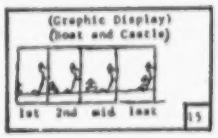
Do you know what seems to happen if things in an animated picture change their position just a little from drawing to drawing?

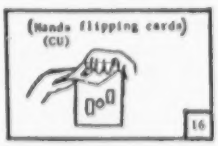
THIS IS ONE IMPORTANT FACTOR ABOUT ANIMATION.

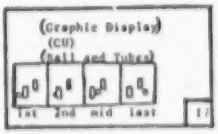
LOOK AGAIN

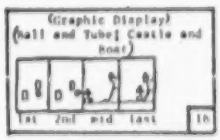












NUMBER 12

Each set of flipcards will have 15 or more cards.

LOOK AGAIN.

NUMBER 13.

In this set of flipcards, the ship sails to the castle.
The action of the ship is animated, so this ship seems to move when the set is flipped.

LOOK AGAIN.

NUMBER 14.

Some parts of an animated picture are in the same place in every flipcard drawing.
But other parts in the picture are in different places from flipcard to flipcard.
In this set the ship is animated, but the castle and the waves are not animated.
The ship is in very different places in the drawings on the first and last flipcards.
But the castle, hill, and waves are each in the same place in all the flipcard drawings.

LOOK AGAIN.

NUMBER 15.

On the first flipcard drawing, the ship that is animated is in the place where it starts.
On the last flipcard drawing, it is where it ends up.
The ship is at places in between in the other flipcard drawings.
It is in very different places in the first and last drawings and in drawings that are far apart from each other in a flipcard set.

LOOK AGAIN.

NUMBER 16.

In this set of flipcards, the ball rolls between the two tanks. The action of the ball is animated, so the ball seems to roll when the set is flipped.

LOOK AGAIN.

NUMBER 17.

The ball is in very different places in the drawings on the first and last flipcards.
But the tanks are in the same place in every flipcard drawing.
The places where the ball is at are not very different in the drawings on the first and second flipcards.
The ball's place in the middle drawing is very different from its place in both the first and last flipcard drawings.

LOOK AGAIN.

NUMBER 18.

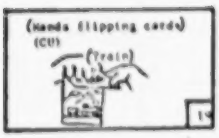
With animated drawings, things seem to move because parts of the picture change their positions just a little from drawing to drawing.
This is one important fact about animation.

LOOK AGAIN.

NUMBER 19.

Another important fact is the order of the flipcards in the set.
Do you know what will seem to move when the flipcards are in the right order and flipped? Will it be the train or the mountains?

LOOK AGAIN



NUMBER 19.

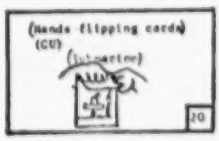
Another important fact about animation is that the drawings must be in the right order or they won't show the planned action. In this set the animated train is moving. When the flipcards are in the right order and flipped, the train will seem to move. But when they are in mixed-up order, they won't show a real motion effect at all.

LOOK AGAIN.

NUMBER 20.

Do you know what is happening in this flipcard set?

LOOK AGAIN



NUMBER 20.

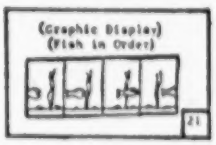
In this set of flipcards the big fish chases and eats the little fish.

LOOK AGAIN.

NUMBER 21.

These four flipcards come one after the other from the middle of a flipcard set.
Do they look like they are in the right order?
Does the big fish seem closer to the little fish from drawing to drawing?

LOOK AGAIN.



NUMBER 21.

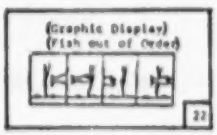
These four flipcards come one after the other from the middle of a flipcard set. They are in the right order. The big fish is closer to the little one from one drawing to the next.

LOOK AGAIN.

NUMBER 22.

These four flipcards come one after the other from the middle of the same flipcard set.
Do they look like they are in the right order?
Do you see why the real action could not be seen with this set?

LOOK AGAIN.



NUMBER 22.

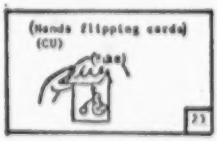
These four flipcards come one after the other. They are from the middle of a flipcard set that is mixed-up.
The real action could not be seen with this set because the flipcards are in the wrong order.

LOOK AGAIN.

NUMBER 23.

Do you know which would be the important things to do in order to see an animated picture? Flipping the cards QUICKLY or flipping them SLOWLY.

LOOK AGAIN



NUMBER 23.

Another fact about animation is that you must see all the drawings quickly, one after the other.

LOOK AGAIN.

NUMBER 24.

Do you see how you change the order of the flipcards if you want to make the planned action happen backwards?
Do you think you will reverse the order of the flipcards?
This is the only way to fix the set so the action happens backwards.
Never flip the set backwards.

LOOK AGAIN.

NUMBER 24.

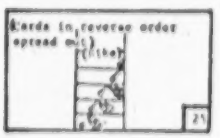
If you want to make the planned action happen backwards, don't flip the set backwards.
To make the action happen backwards, stack the flipcards in the opposite order. Hold them and flip them the right way.

LOOK AGAIN.

NUMBER 25.

Because the order of the flipcard set has been reversed do you know in which direction the bike will go?

LOOK AGAIN.



NUMBER 25.

In flipping this set of cards the man on the bike is going backwards.

LOOK AGAIN.

NUMBER 26.

Now do you know what all moving pictures you see must be made up of?
Do you know four important facts about animated pictures?
Do you know something about the differences from drawing to drawing?
Are the differences big or little?
Do you know something about the order of the drawings?
Must they be in the right or wrong order?
Do you know something about how fast the pictures or drawings must be flipped?
Must they be flipped quickly or slowly?
Do you know how to make the planned action happen backwards?

LOOK AGAIN

NUMBER 27.

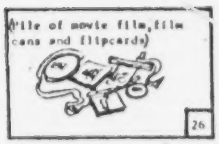
See what is changing its place from flipcard to flipcard. Will it be the train or the mountains?

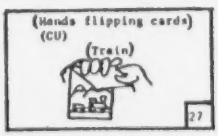
LOOK AGAIN.

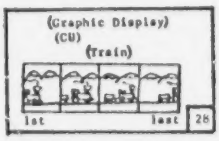
NUMBER 28.

Is the second flipcard in the row very different from any other flipcards?
Do you see which flipcard the 3rd one is only a little different from?
Which flipcard must come just before the last flipcard?
The 3rd one or the 2nd one?
Which flipcard must be from the middle of the flipcard set?
The 1st one or the 2nd one?

LOOK AGAIN.







NUMBER 26.

Any moving picture is really made up of many different pictures or drawings which are changing quickly before your eyes.
Because the drawings are in the right order...
Because parts of the picture are changing position just a little from drawing to drawing, and...
because the drawings are changing quickly...
The picture is animated--you see a drawing that seems to move.
When the cards are stacked in reverse order the action will happen backwards.

LOOK AGAIN.

NUMBER 27.

Now look at flipcards from an other flipcard set.
In this set of flipcards, the train goes along the track. The action of the train is animated, so it seems to move when the set is flipped.

LOOK AGAIN.

NUMBER 28.

The train changes its position from flipcard to flipcard drawing.
Everything else is in the same place in every flipcard drawing.
The second flipcard in the picture is very different from both the first and last flipcards.
It must be from the middle of the flipcard set.
The third flipcard in the picture is only a little different from the last flipcard.
It must come just before the last flipcard.

LOOK AGAIN.

NUMBER 29.

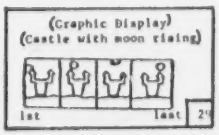
See what is changing position from drawing to drawing.
Look at the 2nd flipcard in the row.
Do you see where it should be in the flipcard set?
Look at the 3rd flipcard in the row.
Do you see where it should be in the flipcard set?
Is which flipcard is the position of the moon very different from its position in all the other flipcard drawings?

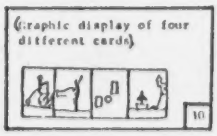
LOOK AGAIN.

NUMBER 30.

So far you have learned about one way of animating a drawn picture.
Do you know what happens to the position of things that are supposed to move?
Do you know about the position of the things that don't move in the animated pictures?

LOOK AGAIN.





NUMBER 29.

In this set of flipcards, the moon is going up in the sky. The moon changes its position from drawing to drawing.
The castle is in the same position in every flipcard drawing.
The second flipcard in the picture must come after the first flipcard.
The moon is in only a little different position.
The third flipcard in the picture must be from the middle of the flipcard set.
The position of the moon in the drawing is very different from its position in the other flipcard drawings.

LOOK AGAIN.

NUMBER 30.

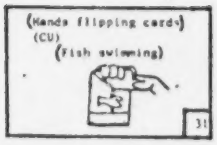
So far you have learned about one way of animating a drawn picture:
1) The things that are supposed to move change their positions from drawing to drawing.
2) The other things in the picture are in the same positions in every flipcard drawing.

LOOK AGAIN.

NUMBER 31.

Look at the position of the plants and rocks in the flipcard swings.
Do you seem to be STANDING STILL watching the fish swim by?
The STANDING STILL kind of animation is one way of animating drawn pictures.

LOOK AGAIN.



NUMBER 31.

In this flipcard set, the plants and rocks are in the same place in every drawing.
It seems like you are STANDING STILL watching the fish swim by. Because of this it is called the STANDING STILL way of animating drawn pictures.
All the flipcard sets you have seen so far use the STANDING STILL way of animating.

LOOK AGAIN.

NUMBER 32.

Do you seem to be STANDING STILL watching the ship?

LOOK AGAIN.

NUMBER 32.

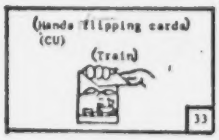
The set with the ship sailing has the STANDING STILL kind of animation. You seem to be standing still watching the ship sail to the castle.

LOOK AGAIN.

NUMBER 33.

Notice what you seem to be doing as you watch the train?
Do you know what kind of animation was used in the other flipcards sets you have seen?

LOOK AGAIN.



NUMBER 33.

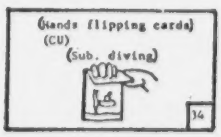
The set with the train is the STANDING STILL kind of flipcard set, too. You seem to be STANDING STILL in one place watching the train go by.

LOOK AGAIN.

NUMBER 34.

Now you will learn another way of animating drawn pictures.
See what is animated in this picture.

LOOK AGAIN.



NUMBER 34.

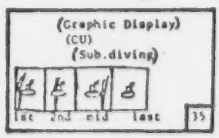
The STANDING STILL kind of animation is one way of making drawn pictures seem to move.
Another way is called the MOVING ALONG kind of animation. When you watch the MOVING ALONG kind of animation you seem to be moving along with the things that are moving.

LOOK AGAIN.

NUMBER 35.

See what seems to stay in the center of each flipcard drawing.
See what changes position from drawing to drawing.
Do the plants and rocks change position from drawing to drawing?
As you watch the sub go by, do you seem to be MOVING ALONG with it, or you you seem to be STANDING STILL watching it go by?

LOOK AGAIN.



NUMBER 35.

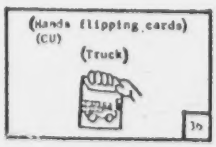
In this set of flipcards, a sub goes down. As you watch the sub go down, you seem to be MOVING ALONG with it, down to the bottom of the sea.
This kind of animation is called the MOVING ALONG kind because you seem to be moving along with the sub.

LOOK AGAIN.

NUMBER 36.

What do you think will stay in the center of the picture, the truck or the fence and the houses?
Do you seem to be MOVING ALONG with the truck as it moves in the street?

LOOK AGAIN.



NUMBER 36.

The truck stays in the center of each drawing. But the fence and the houses change their places from drawing to drawing.
In a MOVING ALONG kind of animated picture, the things that seem to move stay in the center of each drawing, everything else changes its position from drawing to drawing.

LOOK AGAIN.

NUMBER 37.

Notice where the ball is in each drawing?
Do you see what changes position from drawing to drawing?
Do you know what kind of animation is used to make this flipcard set?

LOOK AGAIN.

(Graphic Display)
(CU)
(Ball and Tubes)

37

NUMBER 37.

This flipcard set has the MOVING ALONG kind of animation. As the ball rolls between the tanks, you seem to be moving along with the ball.

LOOK AGAIN.

NUMBER 38.

If the truck stays in the middle of each flipcard drawing, do you know what kind of animation it would be?

LOOK AGAIN.

(Hands flipping cards)
(CU)
(Truck)

38

NUMBER 38.

The truck seems to move, but it stays in the center of each drawing. It is the fence and the houses that change their positions from drawing to drawing.

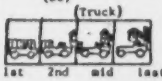
LOOK AGAIN.

NUMBER 39.

Do you see what you seem to be doing as you watch the truck?
Do you see what is happening to the position of the things in the flipcard drawings?

LOOK AGAIN.

(Graphic Display)
(CU)
(Truck)



39

NUMBER 39.

This is a MOVING ALONG set of flipcards. As the truck moves along the street, you seem to be moving along besides it.

LOOK AGAIN.

NUMBER 40.

Now you have seen two ways of animating a drawn picture.
In the STANDING STILL kind of animation, what is supposed to be moving?
See what is changing position from drawing to drawing.
See what is the same position.
What do you seem to be doing as you watch this kind of flipcard animation?

LOOK AGAIN.

(Hands flipping cards)
(CU)
(Castle Boat)

40

NUMBER 40.

Now you know of two ways to animate a drawn picture. There is the STANDING STILL way and the MOVING ALONG way of making drawn pictures seem to move.
In the STANDING STILL way of animating drawings,
1) The thing that is supposed to move changes its position from drawing to drawing.
2) Everything else is in the same position in every drawing.

LOOK AGAIN.

NUMBER 41.

In the MOVING ALONG kind of animation, see what is changing position from drawing to drawing.
See what is in the same position from drawing to drawing.
What do you seem to be doing as you watch this kind of flipcard animation?

LOOK AGAIN.

(Hands flipping cards)
(CU)
(Submarine)

41

NUMBER 41.

In the MOVING ALONG way of animating drawings, the thing that is suppoed to be moving stays in the center of every drawing; everything else changes it position from drawing to drawing.

LOOK AGAIN.

NUMBER 42.

Now is time to find out what you have learned about flipcards and animation.

LOOK AGAIN.

(Graphic Display)

WHAT HAVE YOU LEARNED?

42

NUMBER 42.

Now it is time to find out what you have learned about flipcard and animation.

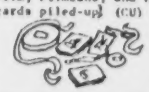
LOOK AGAIN.

NUMBER 43.

You know what animation does for drawn pictures.
You know what an animated picture is made up of.

LOOK AGAIN.

(Film, Filmcans, and Flipcards piled-up) (CU)



43

NUMBER 43.

Animation is a way to make drawn pictures seem to move.
Many drawings are needed.
The drawings may be on movie or on sets of flipcards.

LOOK AGAIN.

NUMBER 44.

You know how small the differences are with flipcards that are close together.
You know how big the differences are with flipcards that are far apart.
You know what is important about the order of the flipcards.

LOOK AGAIN.

NUMBER 45.

You know how fast you have to see animated drawings in order that things in the picture seem to move.

LOOK AGAIN.

NUMBER 46.

You know what to do to make the planned action happens backwards.

LOOK AGAIN.

NUMBER 47.

You know what changes its position in the STANDING STILL kind of animated picture.
You know what stays in the same place in every drawing in this kind of animated picture.
You know what you seem to be doing as you watch the animated action.

LOOK AGAIN.

NUMBER 48.

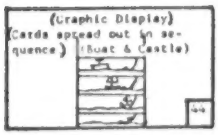
You know what changes position in the MOVING ALONG kind of animated picture. You know where, in each drawing, the thing that is supposed to be moving is in this kind of picture.
You know what you seem to be doing as you watch the animated action.

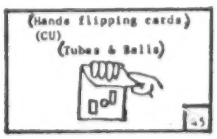
LOOK AGAIN.

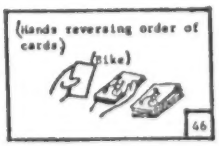
NUMBER 49.

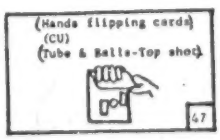
This is the end of the lesson.

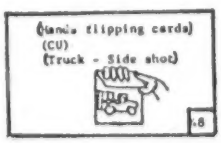
NOW REWIND THE FILMSTRIP, THEN RETURN THE FILMSTRIP AND THE BOOKLET TO THE BOX.

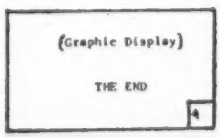












NUMBER 44.

Each drawing is a little different from the others in a flipcard set.
The drawings must be in the right order for any real motion effect.

LOOK AGAIN.

NUMBER 45.

When the drawings are seen one after another, very fast, parts of the picture seem to move.

LOOK AGAIN.

NUMBER 46.

To make the action happen backwards stack the flipcard set in the opposite order.

LOOK AGAIN.

NUMBER 47.

There are two ways of animating drawn pictures. In the STANDING STILL way of animating:
1) the thing that is animated changes its position from drawing to drawing;
2) Everything else stays in the same place in every flipcard drawing. With STANDING STILL kind of picture, what is animated seems to move past as you stand still and watch.

LOOK AGAIN.

NUMBER 48.

In the MOVING ALONG WAY OF ANIMATING:
1) the thing that is animated stays in the center of every drawing;
2) everything else changes its place a little from drawing to drawing. With the MOVING ALONG kind of picture, you seem to move along with the thing that is animated.

LOOK AGAIN.

NUMBER 49.

This is the end of the lesson.
NOW REWIND THE FILMSTRIP
THEN RETURN THE FILMSTRIP AND THIS BOOKLET TO THE BOX.

APPENDIX B

WRITTEN TEST BOOKLET AND PERFORMANCE TEST CHECKLIST

Now that you have finished learning about flipcards and animation, you should be ready to answer some questions,

Read carefully and silently what follows.

First read a question and take whatever time you need to answer the question. Then mark your answer on the line in front of the possible answer and go on to the next question.

Now let us try two sample questions and answers before you begin this test.

Look at this sample question. Read it, silently.

How little or how big are the flipcards? Flipcards are

____ A. Big enough to hold easily in your hand.

____ B. Little enough to be covered up by a postage stamp.

____ C. As big as a safety poster.

Now, put a big "X" in the blank of the right answer.

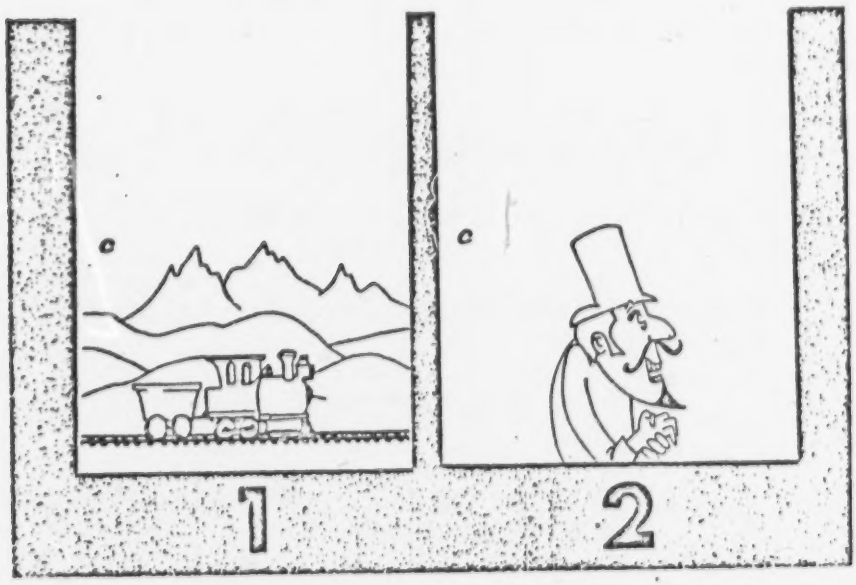
The right answer is "A". Did you put a big "X" in the blank in front of the right answer? Good.

Some questions like the following one, will have pictures for you to look at. The picture will follow the question.

Let's do a sample question with a picture.

Look at the picture after the question. In this case it is a picture of two different flipcards.

What is the number of the picture that goes with each of these descriptions?



___ A. A villain with a grin on his face.

___ B. A steam engine on a railroad track.

This time you put a number in both blanks. The right answers are # 2 for A and # 1 for B.

Now you are ready to begin answering the questions about flipcards and animation. If you don't know the answer to a question, pick the one you think might be the right one. Don't skip any question. If you have to, just guess at an answer.

Now, let us try question # 1.

1. To make the planned action seem to happen, which rule would be the most important rule to follow?

___ A. Flip the flipcards very fast.

___ B. Put the flipcards in the right order.

___ C. Make the top edges of the flipcards even.

---

2. Do you know how fast a set of flipcards must be flipped.

___ A. It must be flipped quickly.

___ B. It must be flipped unevenly.

___ C. It must be flipped slowly.

---

3. Imagine a flipcard set with the background keeping the same position and a moving object changing its position from flipcard to flipcard. The set would be an example of

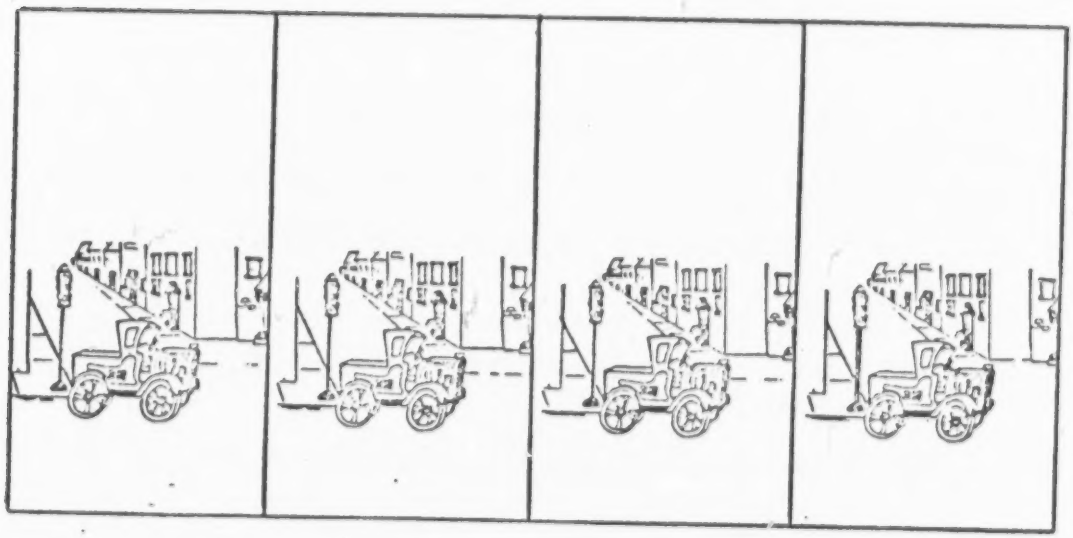
___ A. A set that would not show any action or change.

___ B. A moving along kind of animation.

___ D. A standing still kind of animation.

---

4. Which kind of action the following filpcards will produce?



___ A. These flipcards would not show any action.

___ B. These flipcards would show a moving along kind of animation.

___ C. These flipcards would show an irregular action.

---

5. Rule: To reverse an animated action or change

___ A. Stack the flipcards in exactly the opposite order.

___ B. Flip the flipcards with the opposite hand.

___ C. Flip the flipcards in exactly the opposite direction.

---

6. Which one, if any, of these statements is describing a moving along kind of animated picture?

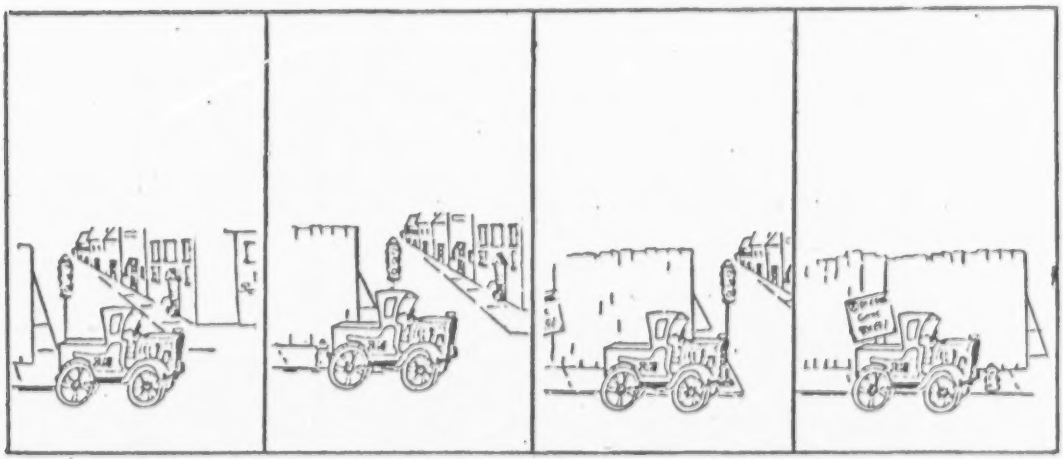
___ A. The thing that is suppose to be moving changes position from flipcard to flipcard.

___ B. The background in the picture doesn't change position from flipcard to flipcard.

___ C. None of these statements describes a moving along kind of animated picture.

---

7. Do the following flipcards look like they are in the right order?



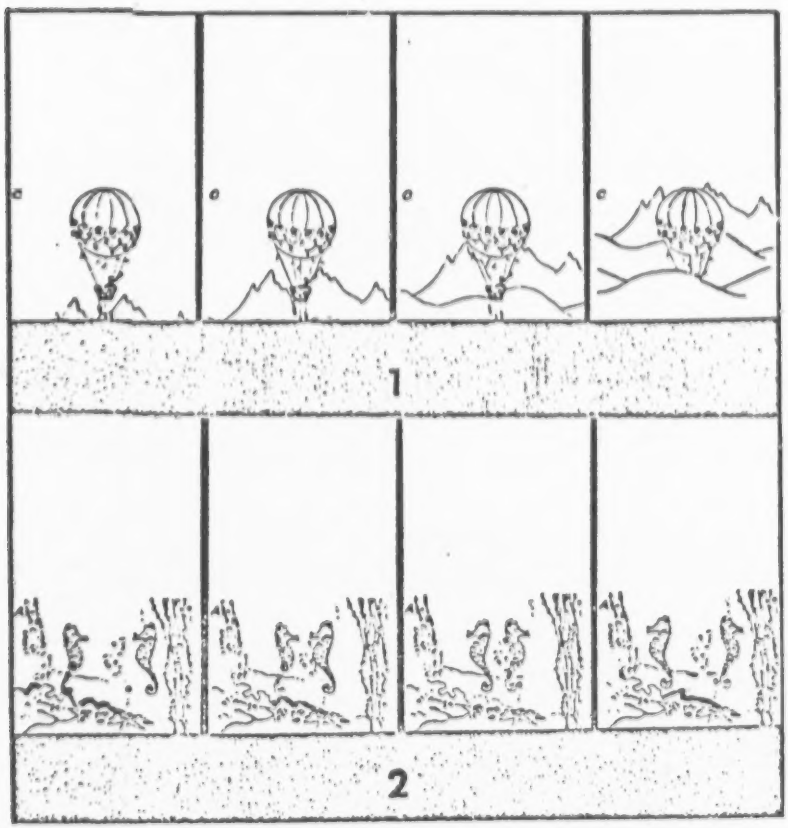
___ A. Yes they look like they are in the right order.

___ B. These flipcards do not come from the same set.

___ C. No they do not look like they were in the right order.

---

8. Which set or sets of flipcards must have the standing still kind of animated picture.



___ A. Set # 1.

___ B. Set # 2.

___ C. Set # 1. and 2

9. Which set of flipcards do you know will not show any animation.

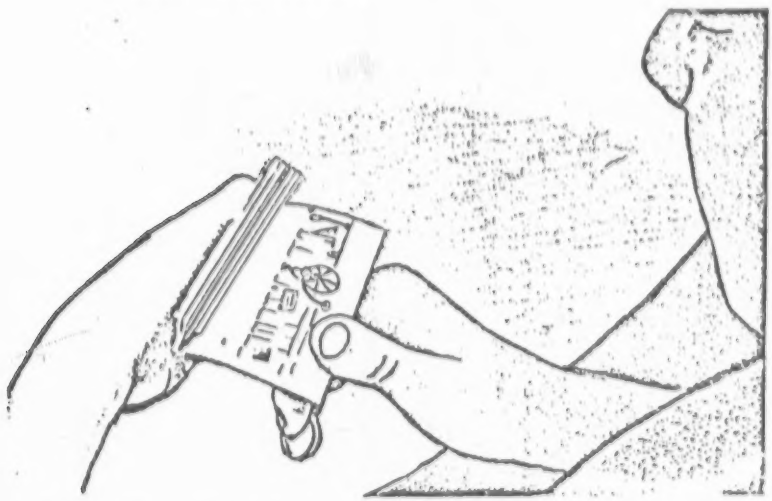
___ A. A set which has flipcards in the reverse order.

___ B. A set which has flipcards that are all just the same.

___ C. A set which has only 15 flipcards.

---

10. Is the boy doing something wrong with the flipcards?



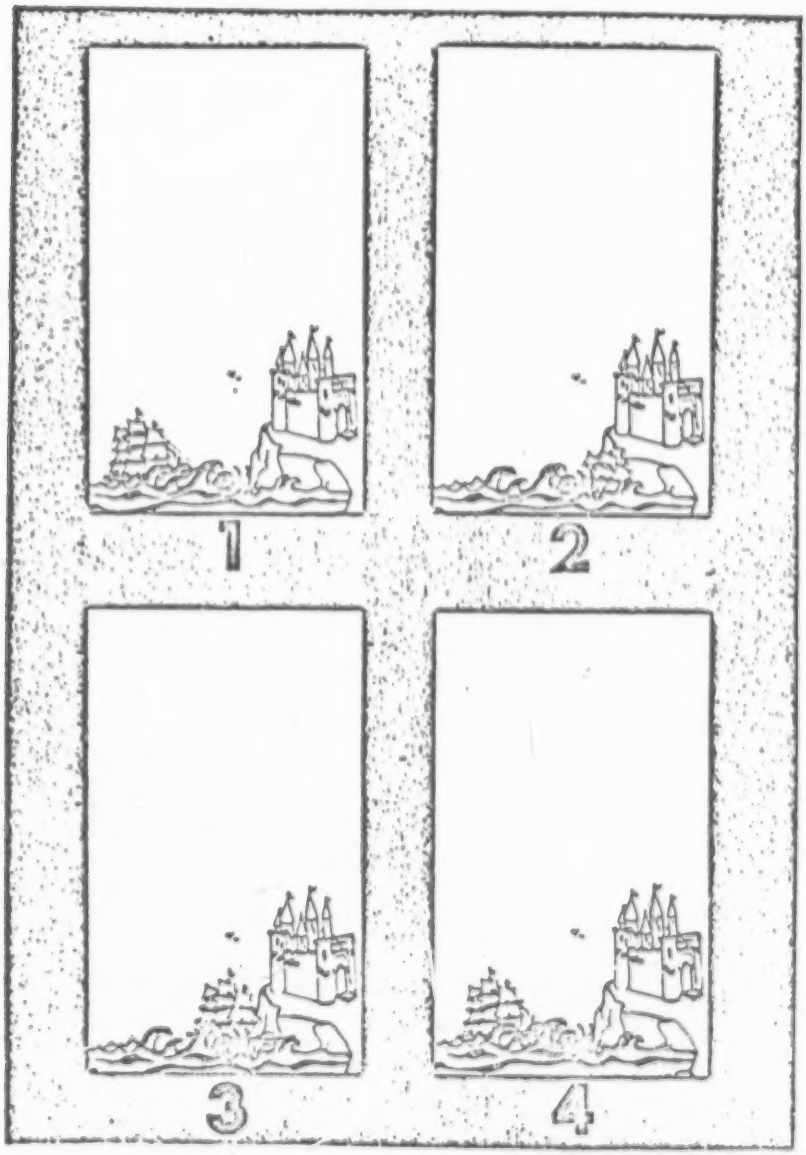
___ A. No. There is no right or wrong way to hold and flip the flipcards.

___ B. No. He is using the flipcards right.

___ C. Yes. He is flipping the flipcards backwards.

---

11. These flipcards are from the set showing the ship sinking. What is the number of the flipcard that would be in the middle of the set?



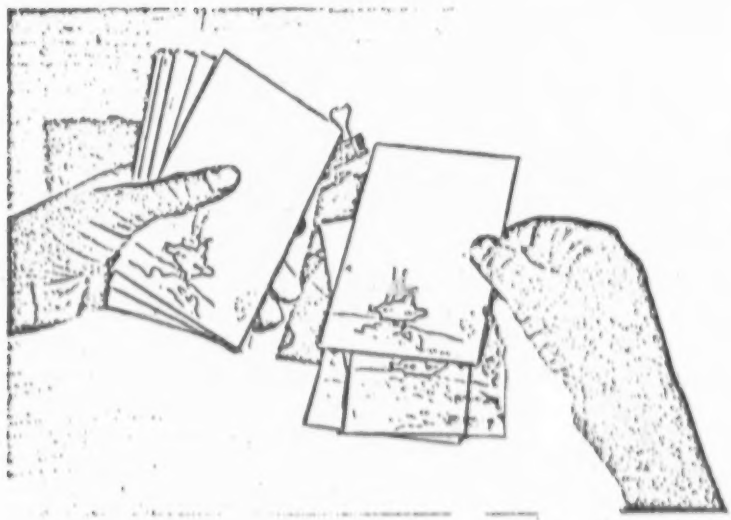
___ A. # 1.

___ B. # 2.

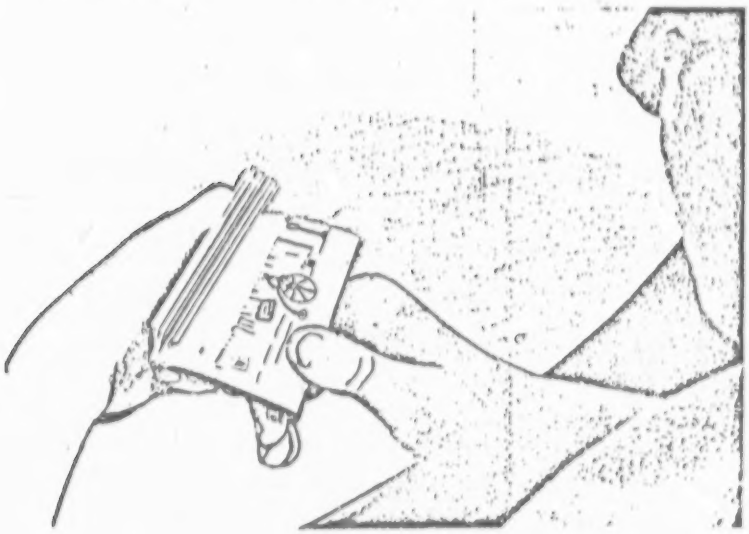
___ C. # 3.

___ D. # 4.

12. Which is the right way to make the action happen in reverse?



A



B

___ A. No right or wrong way shown.

___ B. The way the boy is doing it in picture # 2.

___ C. The way the boy is doing it in picture # 1.

---

13. The right way to use flipcards is

___ A. To flip them in the palm of your hand.

___ B. To flip them on a desk or table top.

___ C. To flip them with your pointing finger.

---

14. The drawing on a flipcard from the middle of a set is

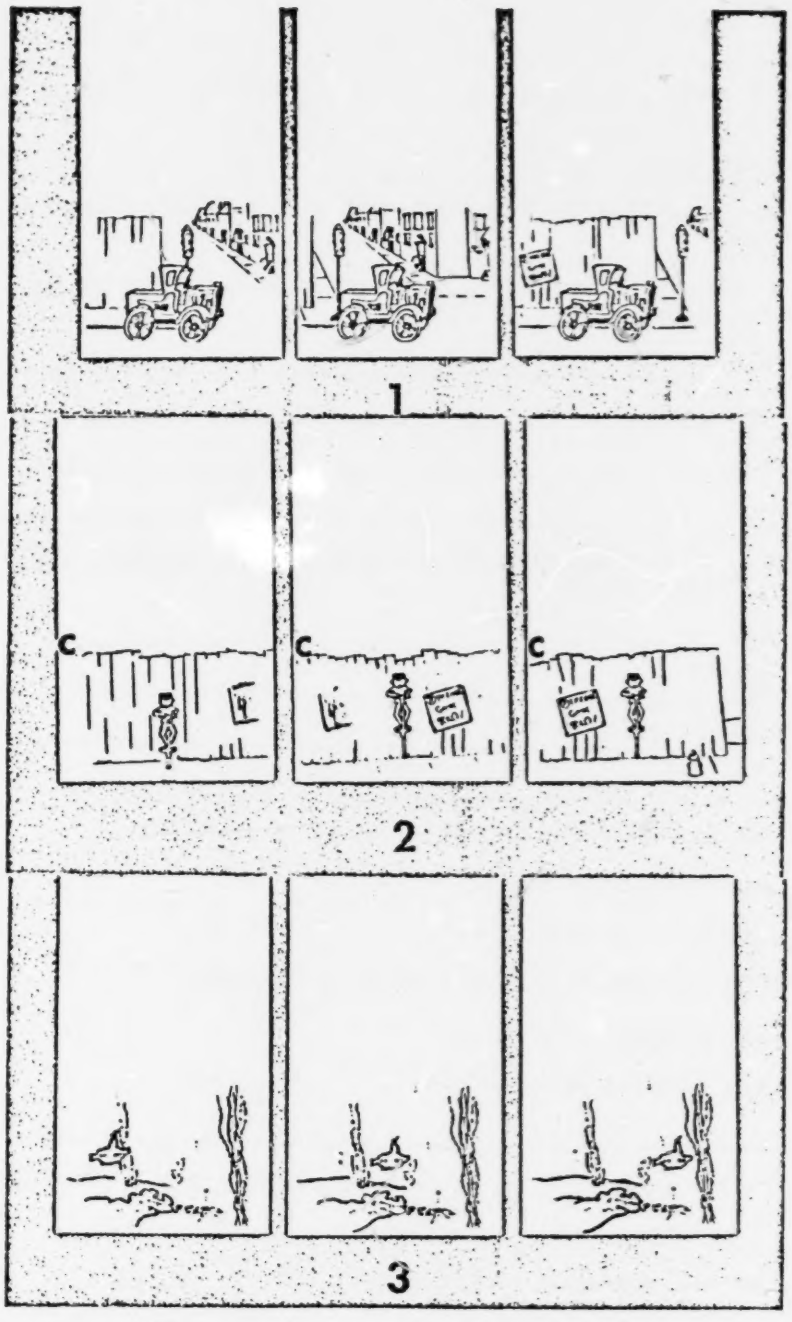
___ A. Very different from every flipcard drawing in the set.

___ B. Only a little different from the first two flipcard drawings.

___ C. A lot different from the first and last flipcard drawings.

---

15. Which set or sets of flipcards must have the <u>moving along</u> kind of animated picture?



___ A. Set # 1.

___ B. Set # 2.

___ C. Set # 3.

___ D. Sets # 1 & # 2.

As soon as you are finished raise your hand.

Student's name _____ number _____.

Performance test.

Using the flipcards in front of you, show me how to do the followings:

1. Which set of flipcards is an example of a moving along type of animation?

   ___ set _____

   ___ set _____

   ___ set _____

2. Which set of flipcards is an example of a standing still type of animation?

   ___ set _____

   ___ set _____

   ___ set _____

3. How do you hold the flipcards to flip them.

   ___ set held correctly.

   ___ set held incorrectly.

4. Show me how you flip this set of flipcards.

   ___ set flipped correctly.

   ___ set flipped incorrectly.

5. Show me how to reverse the action of this set of flipcards.

   ___ action reversed correctly.

   ___ action reversed incorrectly.

6. Show me how to flip the flipcard set in order to make the action happens backwards.

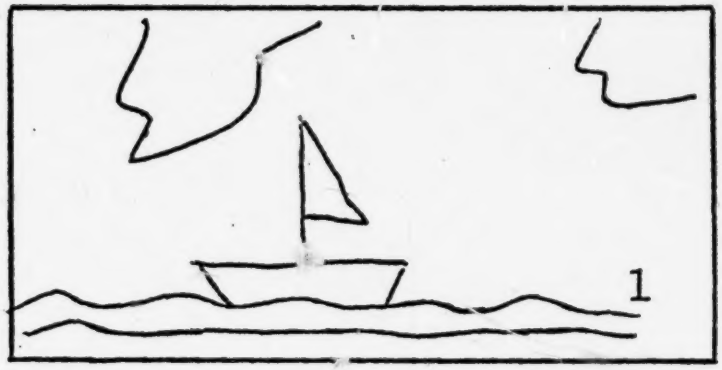
   ___ set flipped correctly.

   ___ set flipped incorrectly.

APPENDIX C

SAMPLE PAGE FROM THE BOOKLETS ACCOMPANYING FILMSTRIP MULTIMEDIA LESSONS

During this little course you will work by yourself without the help of the teacher. The projector in front of you will show a filmstrip picture. On each filmstrip picture you will have a number in the lower right corner like this:



number

Picture

Along with this picture you will have explanations in the booklet which will help you to learn what is on the picture. So it is important to read the booklet <u>first</u> and study the picture <u>after</u>. Each explanation

APPENDIX D

ANALYSIS OF VARIANCE TABLES FOR EXPERIMENTS ONE THROUGH FOUR

TABLE D-1

EXPERIMENT ONE: VERBAL SUBTEST

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F
MEAN	881.04146	1	881.04126	349.54834
AGE	18.04959	1	18.04959	7.16108***
MODE	0.78130	1	0.78130	0.30998
MEDIA	3.02520	1	3.02520	1.20023
A X MO	5.07398	1	5.07398	2.01308
A X ME	0.09837	1	0.09837	0.03903
MEXMO	23.22033	1	23.22032	9.21254***
AXMXM	0.35854	1	0.35854	0.14225
ERROR	98.30000	39	2.52051	

***$p < .01$.

TABLE D-2

EXPERIMENT ONE: PICTORIAL SUBTEST

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F
MEAN	733.73984	1	733.73975	334.03711
AGE	0.08130	1	0.08130	0.03701
MEDIA	0.0	1	0.0	0.0
MODE	5.20325	1	5.20325	2.36880
A X ME	0.32520	1	0.32520	0.14805
A X MO	0.32520	1	0.32520	0.14805
MEXMO	3.98374	1	3.98374	1.81361
AXMXM	0.08130	1	0.08130	0.03701
ERROR	85.66667	39	2.19658	

TABLE D-3

EXPERIMENT ONE: PERFORMANCE TEST

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F
MEAN	307.50000	1	307.49976	186.89607
AGE	0.50813	1	0.50813	0.30884
MEDIA	0.02033	1	0.02033	0.01235
MODE	0.18293	1	0.18293	0.11118
A X ME	0.99593	1	0.99593	0.60532
A X MO	4.57317	1	4.57317	2.77954
MEXMO	0.50813	1	0.50813	0.30884
AXMXM	4.57317	1	4.57317	2.77954
ERROR	64.16667	39	1.64530	

TABLE D-4

EXPERIMENT ONE: TOTAL TEST

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F
MEAN	5521.33008	1	5521.32812	680.42505
AGE	27.52520	1	27.52519	3.39209*
MEDIA	0.54959	1	0.54959	0.06773
MODE	12.90732	1	12.90732	1.59064
A X ME	3.33008	1	3.33008	0.41039
A X MO	1.57398	1	1.57398	0.19397
MEXMO	37.23252	1	37.23251	4.58838**
AXMXM	1.57398	1	1.57398	0.19397
ERROR	316.46667	39	8.11453	

*$p < .10$.
**$p < .05$.

TABLE D-5

EXPERIMENT ONE: LESSON TIME

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F
MEAN	45087.64959	1	45087.64844	2091.61328
AGE	217.30813	1	217.30812	10.08091***
MEDIA	753.95854	1	753.95850	34.97609***
MODE	31.55203	1	31.55203	1.46370
A X ME	22.67398	1	22.67398	1.05184
A X MO	0.03984	1	0.03984	0.00185
MEXMO	6.15366	1	6.15366	0.28547
AXMXM	4.82033	1	4.82032	0.22361
ERROR	840.70000	39	21.55640	

***$p < .01$.

TABLE D-6

EXPERIMENT ONE: WRITTEN TEST TIME

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F
MEAN	8592.68374	1	8592.68359	537.93359
AGE	172.78130	1	172.78130	10.81674***
MEDIA	144.09837	1	144.09837	9.02109
MODE	26.63496	1	26.63495	1.66745
A X ME	78.63496	1	78.63495	4.92284**
A X MO	29.65935	1	29.65935	1.85678
MEXMO	23.77317	1	23.77316	1.48829
AXMXM	94.53740	1	94.53738	5.91839***
ERROR	622.96667	39	15.97350	

**$p < .05$.
***$p < .01$.

TABLE D-7

EXPERIMENT ONE: TOTAL TIME

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F
MEAN	104162.40732	1	104162.37500	2273.31274
AGE	763.38293	1	763.38281	16.66060***
MEDIA	255.87073	1	255.87073	5.58430**
MODE	93.43171	1	93.43170	2.03912
A X ME	163.90325	1	163.90324	3.57714*
A X MO	35.51301	1	35.51300	0.77506
MEXMO	54.53740	1	54.53738	1.19026
AXMXM	136.00081	1	136.00081	2.96818
ERROR	1786.96667	39	45.81964	

*p < .10.
**p < .05.
***p < .01.

TABLE D-8

EXPERIMENT TWO: VERBAL SUBTEST

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F
MEAN	946.53740	1	946.53735	418.06299
AGE	29.65935	1	29.65935	13.09983***
MEDIA	0.06585	1	0.06585	0.02909
MODE	0.68374	1	0.68374	0.30199
A X ME	0.00081	1	0.00081	0.00036
A X MO	5.33415	1	5.33415	2.35596
MEXMO	1.36667	1	1.36667	0.60362
AXMXM	9.65935	1	9.65935	4.26630**
ERROR	88.30000	39	2.26410	

**p < .05.
***p < .01.

TABLE D-9

EXPERIMENT TWO: PICTORIAL SUBTEST

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F
MEAN	798.43984	1	798.43970	392.67529
AGE	6.43984	1	6.43984	3.16713*
MEDIA	5.33415	1	5.33415	2.62335
MODE	5.33415	1	5.33415	2.62335
A X ME	1.23659	1	1.23658	0.60816
A X MO	0.35854	1	0.35854	0.17633
MEXMO	0.06585	1	0.06585	0.03239
AXMXM	0.68374	1	0.68374	0.33627
ERROR	79.30000	39	2.03333	

*p < .10.

TABLE D-10

EXPERIMENT TWO: PERFORMANCE TEST

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F
MEAN	435.62927	1	435.62915	143.33134
AGE	9.48293	1	9.48293	3.12009*
MEDIA	8.45854	1	8.45654	2.78304
MODE	0.11707	1	0.11707	0.03852
A X ME	1.43415	1	1.43415	0.47186
A X MO	1.87317	1	1.87317	0.61631
MEXMO	3.12520	1	3.12520	1.02826
AXMXM	0.39350	1	0.39350	0.12947
ERROR	118.53333	39	3.03932	

*$p < .10$.

TABLE D-11

EXPERIMENT TWO: TOTAL TEST

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F
MEAN	6405.89350	1	6405.89062	473.43140
AGE	125.56829	1	125.56828	9.28020***
MEDIA	28.43008	1	28.43007	2.10114
MODE	11.12927	1	11.12927	0.82252
A X ME	0.03984	1	0.03984	0.00294
A X MO	8.62520	1	8.62520	0.63745
MEXMO	0.23496	1	0.23496	0.01736
AXMXM	7.64959	1	7.64959	0.56535
ERROR	527.70000	39	13.53077	

***$p < .01$.

TABLE D-12

EXPERIMENT TWO: LESSON TIME

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F
MEAN	42099.52520	1	42099.52344	1297.79370
AGE	638.20813	1	638.20801	19.67390***
MEDIA	1.72033	1	1.72032	0.05303
MODE	113.72033	1	113.72032	3.50563*
A X ME	206.51707	1	206.51706	6.36626**
A X MO	16.85854	1	16.85854	0.51969
MEXMO	464.66341	1	464.66333	14.32409***
AXMXM	14.59837	1	14.59837	0.45002
ERROR	1265.13333	39	32.43930	

*p < .10.
**p < .05.
***p < .01.

TABLE D-13

EXPERIMENT TWO: WRITTEN TEST TIME

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F
MEAN	7567.96829	1	7567.96484	483.08789
AGE	188.09837	1	188.09837	12.00694***
MEDIA	42.63496	1	42.63495	2.72153
MODE	72.68374	1	72.68373	4.63964**
A X ME	38.99268	1	38.99268	2.48903
A X MO	3.87073	1	3.87073	0.24708
MEXMO	21.07398	1	21.07397	1.34522
AXMXM	2.11463	1	2.11463	0.13498
ERROR	610.96667	39	15.66581	

**p < .05.
***p < .01.

TABLE D-14

EXPERIMENT TWO: TOTAL TIME

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F
MEAN	94759.03740	1	94759.00000	1298.31177
AGE	1517.03740	1	1517.03735	20.78522***
MEDIA	37.23252	1	37.23251	0.51013
MODE	337.18374	1	337.18359	4.61982**
A X ME	474.54959	1	474.54956	6.50190**
A X MO	30.59837	1	30.59837	0.41923
MEXMO	554.69593	1	554.69580	7.60000***
AXMXM	5.73659	1	5.73658	0.07860
ERROR	2846.46667	39	72.98631	

**$p < .05$.

***$p < .01$.

TABLE D-15

EXPERIMENT THREE: VERBAL SUBTEST

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F
MEAN	1200.00000	1	1199.99976	672.89722
AGE	12.00000	1	12.00000	6.72897**
MEDIA	0.33333	1	0.33333	0.18692
MODE	0.33333	1	0.33333	0.18692
A X ME	1.33333	1	1.33333	0.74766
A X MO	0.0	1	0.0	0.0
MEXMO	5.33333	1	5.33333	2.99065*
AXMXM	1.33333	1	1.33333	0.74766
ERROR	71.33333	40	1.78333	

*p < .10.
**p < .05.

TABLE D-16

EXPERIMENT THREE: PICTORIAL SUBTEST

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F
MEAN	954.08333	1	954.08325	457.95996
AGE	3.00000	1	3.00000	1.44000
MEDIA	8.33333	1	8.33333	4.00000**
MODE	3.00000	1	3.00000	1.44000
A X ME	2.08333	1	2.08333	1.00000
A X MO	0.75000	1	0.75000	0.36000
MEXMO	0.08333	1	0.08333	0.04000
AXMXM	1.33333	1	1.33333	0.64000
ERROR	83.33333	40	2.08333	

**p < .05.

TABLE D-17

EXPERIMENT THREE: PERFORMANCE TEST

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F
MEAN	462.52083	1	462.52075	219.81190
AGE	13.02083	1	13.02083	6.18812**
MEDIA	2.52083	1	2.52083	1.19802
MODE	1.02083	1	1.02083	0.48515
A X ME	0.18750	1	0.18750	0.08911
A X MO	0.52083	1	0.52083	0.24752
MEXMO	0.52083	1	0.52083	0.24752
AXMXM	0.52083	1	0.52083	0.24752
ERROR	84.16667	40	2.10417	

**$p < .05$.

TABLE D-18

EXPERIMENT THREE: TOTAL TEST

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F
MEAN	7575.18750	1	7575.18359	919.59790
AGE	77.52083	1	77.52083	9.41073***
MEDIA	25.52083	1	25.52083	3.09813*
MODE	0.02083	1	0.02083	0.00253
A X ME	9.18750	1	9.18750	1.11533
A X MO	0.02083	1	0.02083	0.00253
MEXMO	7.52083	1	7.52083	0.91300
AXMXM	0.52083	1	0.52083	0.06323
ERROR	329.50000	40	8.23749	

*$p < .10$.
***$p < .01$.

TABLE D-19

EXPERIMENT THREE: LESSON TIME

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F
MEAN	51679.68750	1	51679.68359	2720.58179
AGE	9.18750	1	9.18750	0.48366
MEDIA	238.52083	1	238.52083	12.55649***
MODE	38.52083	1	38.52083	2.02786
A X ME	11.02083	1	11.02083	0.58017
A X MO	3.52083	1	3.52083	0.18535
MEXMO	77.52083	1	77.52083	4.08094**
AXMXM	117.18750	1	117.18750	6.16912**
ERROR	759.83333	40	18.99582	

**p < .05.
***p < .01.

TABLE D-20

EXPERIMENT THREE: WRITTEN TEST TIME

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F
MEAN	8829.18750	1	8829.18359	425.07593
AGE	58.52083	1	58.52083	2.81745*
MEDIA	31.68750	1	31.68750	1.52558
MODE	35.02083	1	35.02083	1.68606
A X ME	1.02083	1	1.02083	0.04915
A X MO	0.18750	1	0.18750	0.00903
MEXMO	17.52083	1	17.52083	0.84353
AXMXM	35.02083	1	35.02083	1.68606
ERROR	830.83333	40	20.77083	

*p < .10.

TABLE D-21

EXPERIMENT THREE: TOTAL TIME

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F	
MEAN	115835.75000	1	115836.68750	2534.72046	
AGE	36.75000	1	36.75000	0.80416	
MEDIA	374.08333	1	374.08325	8.18563	***
MODE	10.08333	1	10.08333	0.22064	
A X ME	0.75000	1	0.75000	0.01641	
A X MO	0.75000	1	0.75000	0.01641	
MEXMO	140.08333	1	140.08333	3.06528	*
AXMXM	330.75000	1	330.75000	7.23742	***
ERROR	1828.00000	40	45.69998		

*p < .10.
***p < .01.

TABLE D-22

EXPERIMENT FOUR: VERBAL SUBTEST

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F
MEAN	892.68750	1	892.68726	526.40015
AGE	13.02083	1	13.02083	7.67813***
MEDIA	7.52083	1	7.52083	4.43489**
MODE	1.02083	1	1.02083	0.60197
A X ME	0.18750	1	0.18750	0.11057
A X MO	2.52083	1	2.52083	1.48649
MEXMO	3.52083	1	3.52083	2.07617
AXMXM	22.68750	1	22.68750	13.37838***
ERROR	67.83333	40	1.69583	

**p < .05.
***p < .01.

TABLE D-23

EXPERIMENT FOUR: PICTORIAL SUBTEST

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F
MEAN	792.18750	1	792.18726	398.58472
AGE	38.52083	1	38.52083	19.38155***
MEDIA	11.02083	1	11.02083	5.54507**
MODE	0.52083	1	0.52083	0.26205
A X ME	0.02083	1	0.02083	0.01048
A X MO	4.68750	1	4.68750	2.35849
MEXMO	0.02083	1	0.02083	0.01048
AXMXM	0.52083	1	0.52083	0.26205
ERROR	79.50000	40	1.98750	

**p < .05.
***p < .01.

TABLE D-24

EXPERIMENT FOUR: PERFORMANCE TEST

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F
MEAN	468.75000	1	468.74976	184.42618***
AGE	24.08333	1	24.08333	9.47541
MEDIA	5.33333	1	5.33333	2.09836
MODE	0.33333	1	0.33333	0.13115
A X ME	0.33333	1	0.33333	0.13115
A X MO	5.33333	1	5.33333	2.09836
MEXMO	2.08333	1	2.08333	0.81967
AXMXM	2.08333	1	2.08333	0.81967
ERROR	101.66667	40	2.54167	

***$p < .01$.

TABLE D-25

EXPERIMENT FOUR: TOTAL TEST

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F
MEAN	6348.00000	1	6347.99609	932.38647
AGE	216.75000	1	216.75000	31.83598***
MEDIA	70.08333	1	70.08333	10.29376***
MODE	1.33333	1	1.33333	0.19584
A X ME	1.33333	1	1.33333	0.19584
A X MO	2.08333	1	2.08333	0.30600
MEXMO	10.08333	1	10.08333	1.48103
AXMXM	48.00000	1	48.00000	7.05019**
ERROR	272.33333	40	6.80833	

**$p < .05$.
***$p < .01$.

TABLE D-26

EXPERIMENT FOUR: LESSON TIME

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F
MEAN	26980.08333	1	26980.08203	520.51587
AGE	14.08333	1	14.08333	0.27170
MEDIA	0.33333	1	0.33333	0.00643
MODE	56.33333	1	56.33333	1.08682
A X ME	1.33333	1	1.33333	0.02572
A X MO	8.33333	1	8.33333	0.16077
MEXMO	80.08333	1	80.08333	1.54502
AXMXM	0.08333	1	0.08333	0.00161
ERROR	2073.33333	40	51.83333	

TABLE D-27

EXPERIMENT FOUR: WRITTEN TEST TIME

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F
MEAN	7600.33333	1	7600.33203	760.03320
AGE	75.00000	1	75.00000	7.50000***
MEDIA	85.33333	1	85.33333	8.53333***
MODE	1.33333	1	1.33333	0.13333
A X ME	16.33333	1	16.33333	1.63333
A X MO	0.33333	1	0.33333	0.03333
MEXMO	27.00000	1	27.00000	2.70000
AXMXM	0.33333	1	0.33333	0.03333
ERROR	400.00000	40	10.00000	

***$p < .01$.

TABLE D-28

EXPERIMENT FOUR: TOTAL TIME

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F
MEAN	73398.52083	1	73398.50000	1119.94653
AGE	42.18750	1	42.18750	0.64372
MEDIA	212.52083	1	212.52083	3.24274*
MODE	9.18750	1	9.18750	0.14019
A X ME	77.52083	1	77.52083	1.18285
A X MO	2.52083	1	2.52083	0.03846
MEXMO	123.52083	1	123.52083	1.88474
AXMXM	7.52083	1	7.52083	0.11476
ERROR	2621.50000	40	65.53749	

*$p < .10$.